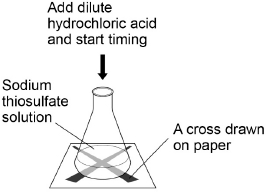
**Q1.** A student investigates the effect of concentration on the rate of reaction.The student reacts sodium thiosulfate solution with dilute hydrochloric acid.This produces a cloudy mixture.

(a)     The cloudiness is produced by the formation of solid sulfur. How should sulfur be written in the chemical equation for this reaction? Tick (✔) **one** box.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| S(aq) |  |  | S(g) |  |  | S(l) |  |  | S(s) |  |

**(1)**

The diagram shows some of the apparatus the student uses.



This is the method used.

1. Measure 40 cm 3 sodium thiosulfate solution into a conical flask.

2. Stand the flask on a piece of paper with a cross drawn on it.

3. Add 10 cm 3 of dilute hydrochloric acid to the flask.

4. Time how long it takes the cross to become no longer visible.

5. Repeat steps 1‒4 twice more.

6. Repeat steps 1‒5 with sodium thiosulfate solutions of different concentrations.

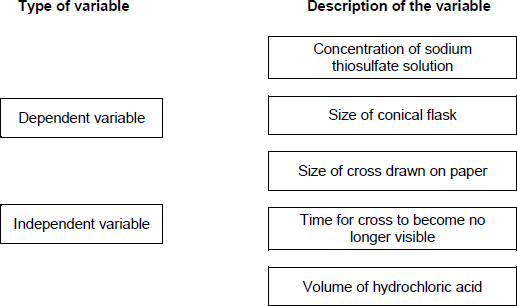
**(1)**

(b)     Which apparatus could be used to measure 10 cm3 of dilute hydrochloric acid? Tick (✔) **one** box.

|  |  |
| --- | --- |
| Beaker |  |
| Boiling tube |  |
| Measuring cylinder |  |
| Test tube |  |

**(1)**

(c)     Draw **one** line from each type of variable to the description of the variable.



**(2)**

(d)     The student draws a new cross for each experiment.

Suggest why this might give inaccurate results.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(e)     The table shows the student’s results for sodium thiosulfate solution with a concentration of 12 g / dm3

|  |  |  |  |
| --- | --- | --- | --- |
| **Time for cross to become no longer visible in s** | | | |
| **Trial 1** | **Trial 2** | **Trial 3** | **Mean** |
| 43 | 78 | 41 | **X** |

Calculate value **X** in the tabble.

Do **not** use any anomalous results in your calculation.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**X** = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ s

**(2)**

(f)      The graph shows some of the student’s results.



Draw a smooth curve of best fit on the graph above.

**(1)**

(g)     Another student does the same investigation. Both students have a similar pattern in their results. Which word describes investigations performed by different students, which give a similar pattern of results?

Tick (✔) **one** box.

|  |  |
| --- | --- |
| Accurate |  |
| Precise |  |
| Reproducible |  |
| Valid |  |

**(1)**

(h)     The more concentrated the sodium thiosulfate solution, the less time is taken for the cross to become no longer visible. Give **two** reasons why. Tick (✔) **two** boxes.

|  |  |
| --- | --- |
| Particles are more spread out |  |
| Particles collide more frequently |  |
| Particles have more energy |  |
| Particles move more quickly |  |
| There are more particles in a fixed volume |  |

**(2)**

**(Total 11 marks)**

**Q2.**

(a)     The figure below represents the reaction of sulfur dioxide with oxygen.

Oxygen   
Sulfur dioxide  Sulfur trioxide

(i)      Complete the word equation for the reaction of sulfur dioxide with oxygen.

sulfur dioxide    +    \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_        \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(ii)     Draw a ring around the correct answer to complete the sentence.

|  |  |
| --- | --- |
| Sulfur dioxide (SO2) is | a compound.  an element.  a mixture. |

**(1)**

(b)     The reactants are gases.

When the pressure of the gases is increased, the reaction gets faster.

Complete the sentence.

When the pressure of the gases is increased,

the frequency of the collisions \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ .

**(1)**

(c)     The particles need energy to react.

Complete the sentence.

The minimum amount of energy that particles need to react is called

the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ energy.

**(1)**

(d)     Give **one** way of increasing the rate of the reaction other than changing the pressure.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

**(Total 5 marks)**

**Q3.** When sodium thiosulfate solution reacts with dilute hydrochloric acid, the solution becomes cloudy.

The equation for the reaction is:

Na2S2O3(aq) + 2 HCl(aq) ⟶ 2 NaCl(aq) + SO2(g) + H2O(l) + S(s)

(a)     Why does the solution become cloudy?

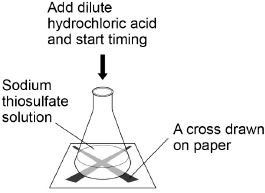
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**(2)**

Some students used this reaction to investigate the effect of concentration on rate of reaction. The diagram shows the apparatus used.



This is the method used.

1. Measure 25 cm3 sodium thiosulfate solution into a conical flask.

2. Stand the conical flask on a cross drawn on paper.

3. Add 10 cm3 of dilute hydrochloric acid.

4. Time how long it takes the cross to become no longer visible.

5. Repeat steps 1–4 with sodium thiosulfate solutions of different concentrations.

(b)     The students used a measuring cylinder to measure 25 cm3 of sodium thiosulfate solution. Suggest a more accurate way of measuring 25 cm3 of sodium thiosulfate solution.

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**(1)**

(c)     Name one control variable the students should use in this investigation.

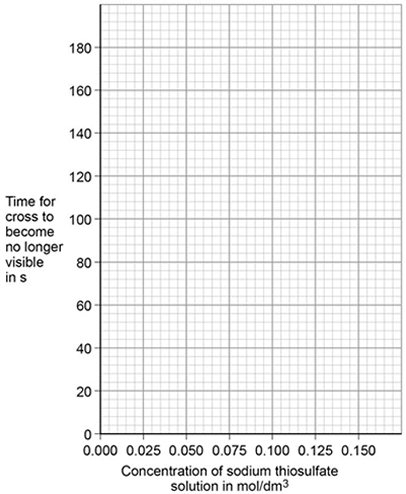
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**(1)**

The table shows the students’ results.

|  |  |
| --- | --- |
| **Concentration of sodium thiosulfate solution in mol / dm3** | **Time for cross to become no longer visible in s** |
| 0.020 | 170 |
| 0.040 | 90 |
| 0.060 | 82 |
| 0.080 | 42 |
| 0.100 | 34 |
| 0.120 | 30 |
| 0.140 | 28 |

(d)     Plot the data from the table above on the graph below. Draw a line of best fit.



**(3)**

The students repeated the investigation two more times. They obtained similar results each time.

(e)     What word describes an investigation by the same students which gives similar results each time?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(f)      Describe how the students can use their results to improve the accuracy of the investigation.

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**(2)**

(g)     The students analysed their results to give a conclusion and an explanation for their investigation.

**Conclusion:** ‘The higher the concentration, the lower the rate of reaction.’

**Explanation:** ‘At higher concentrations, the particles have more energy, so they are moving faster. Therefore the collisions are more energetic.’

The students are not correct. Give a **correct** conclusion **and** explanation for the results of the investigation.

Conclusion \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Explanation \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(3)**

(h)     A solution containing 0.18 g of sodium thiosulfate reacts with dilute hydrochloric acid in 2 minutes. Calculate the mean rate of reaction in g / s. Give your answer in standard form.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Mean rate of reaction = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g / s

**(3)**

**(Total 16 marks)**

**Q4.** Cobalt forms coloured compounds.A pink cobalt compound reacts with hydrochloric acid.

The reaction can be represented as:

pink cobalt compound + hydrochloric acid ⇌ blue cobalt compound + water

The forward reaction is endothermic. When both cobalt compounds are present in a solution at equilibrium, the equilibrium mixture is purple.

(a)     What is meant by equilibrium?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(b)     The equilibrium mixture is cooled. Explain what happens to the concentration of the pink cobalt compound.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(3)**

(c)     More hydrochloric acid is added. Explain what happens to the colour of the equilibrium mixture

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(3)**

(d)     Why does cobalt form different coloured compounds?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(e)     An oxide of cobalt has the formula Co2O3

Which cobalt ion is present in this oxide?

Tick (✔) **one** box.

|  |  |
| --- | --- |
| Co+ |  |
| Co2+ |  |
| Co3+ |  |
| Co4+ |  |

**(1)**

(f)      Cobalt compounds can act as catalysts.

Which two statements about cobalt compounds are correct?

Tick (✔) **two** boxes.

|  |  |
| --- | --- |
| They allow reactions to reach equilibrium more quickly. |  |
| They are reactants in reactions catalysed by cobalt compounds. |  |
| They are used up when acting as catalysts. |  |
| They increase the equilibrium yield of reactions. |  |
| They provide a different reaction pathway. |  |

**(2)**

(g)     The reaction of hydrogen with carbon monoxide is catalysed by cobalt metal.

Balance the equation for the reaction.

H2  +  CO  ⟶  C6H14  +  H2O

**(1)**

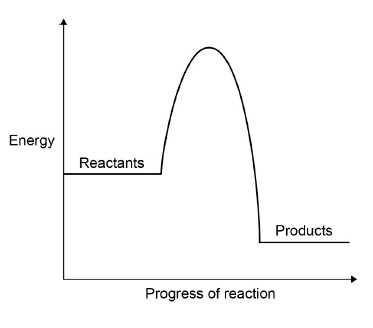
(h)     C6H14 is an alkane.

What is the formula of an alkane containing 18 hydrogen atoms?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(i)      The graph shows a reaction profile diagram for a reaction **without** a catalyst.



On the graph:

•   draw the reaction profile diagram for a catalysed reaction

•   draw and label an arrow to show the activation energy for the reaction **without** a catalyst.

**(2)**

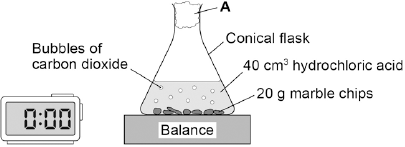
**(Total 16 marks)**

**Q5.**

A student investigated the rate of reaction between marble chips and hydrochloric acid.

**Figure 1** shows the apparatus the student used.

**Figure 1**

****

(a)     What is **A**?

|  |  |
| --- | --- |
| Tick **one** box. |  |
| cotton wool |  |
| limestone |  |
| poly(ethene) |  |
| rubber bung |  |

**(1)**

(b)     **Table 1** shows the student’s results for one investigation.

**Table 1**

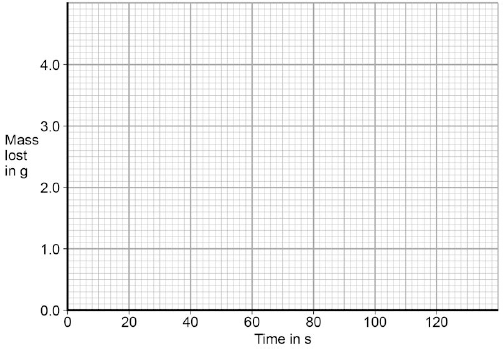
|  |  |  |
| --- | --- | --- |
|  | **Time**  **in s** | **Mass lost**  **in g** |
|  | 0 | 0.0 |
|  | 20 | 1.6 |
|  | 40 | 2.6 |
|  | 60 | 2.9 |
|  | 80 | 3.7 |
|  | 100 | 4.0 |
|  | 120 | 4.0 |

On **Figure 2**:

•        Plot these results on the grid.

•        Draw a line of best fit.

**Figure 2**

****

**(3)**

(c)     Use **Figure 2** to complete **Table 2**.

**Table 2**

|  |  |
| --- | --- |
| Mass lost after 0.5 minutes | \_\_\_\_\_\_ g |
| Time taken to complete the reaction | \_\_\_\_\_\_ s |

**(2)**

(d)     The equation for the reaction is:

2HCl(aq)    +   CaCO3(s)   →   CaCl2(aq)   +   H2O(l)   +   CO2(g)

Explain why there is a loss in mass in this investigation.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(e)     Another student investigated the rate of a different reaction.

**Table 3** shows the results from the different reaction.

**Table 3**

|  |  |
| --- | --- |
| Mass lost when the reaction was complete | 9.85 g |
| Time taken to complete the reaction | 2 minutes 30 seconds |

Calculate the mean rate of the reaction using **Table 3** and the equation:

                        mean rate of reaction = 

Give your answer to two decimal places.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Mean rate of reaction = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g / s

**(2)**

(f)     The student measured the change in mass of the reactants.

Describe another method, other than measuring the change in mass of the reactions, that the student could have used to find the rate of the reaction between marble chips and hydrochloric acid.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(g)     Another student planned to investigate the effect of temperature on the rate of reaction.

The student predicted that the rate of reaction would increase as the temperature was increased.

Give **two** reasons why the student’s prediction is correct.

|  |  |
| --- | --- |
| Tick **two** boxes. |  |
| The particles are more concentrated. |  |
| The particles have a greater mass. |  |
| The particles have a larger surface area. |  |
| The particles have more energy. |  |
| The particles move faster. |  |

**(2)**

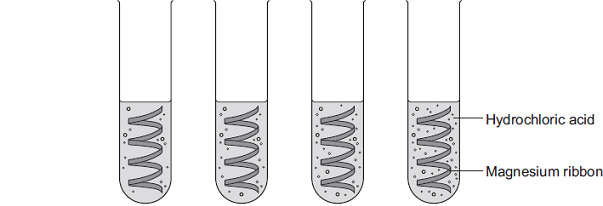
**(Total 14 marks)**

**Q6.** A student investigated the rate of reaction of magnesium and hydrochloric acid.

Mg(s) + 2HCl(aq)    MgCl2(aq)  +  H2(g)

The student studied the effect of changing the concentration of the hydrochloric acid.

She measured the time for the magnesium to stop reacting.



|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Concentration of hydrochloric acid in moles per dm3 | 0.5 | 1.0 | 1.5 | 2.0 |

(a)     The student changed the concentration of the hydrochloric acid.

Give **two** variables that the student should control.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(b)     (i)      The rate of reaction increased as the concentration of hydrochloric acid increased.

Explain why.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(ii)     Explain why increasing the temperature would increase the rate of reaction.

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**(3)**

(c)     (i)      The student had a solution of sodium hydroxide with a concentration of 0.100 moles per dm3. She wanted to check the concentration of a solution of hydrochloric acid.

She used a pipette to transfer 5.00 cm3 of the hydrochloric acid into a conical flask.

She filled a burette with the 0.100 moles per dm3 sodium hydroxide solution.

Describe how she should use titration to obtain accurate results.

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**(4)**

(ii)     Sodium hydroxide neutralises hydrochloric acid as shown in the equation:

NaOH(aq)  +  HCl(aq)    NaCl(aq) + H2O(l)

The student found that 27.20 cm3 of 0.100 moles per dm3 sodium hydroxide neutralised 5.00 cm3 of hydrochloric acid. Calculate the concentration of the hydrochloric acid in moles per dm3. Give your answer to three significant figures.

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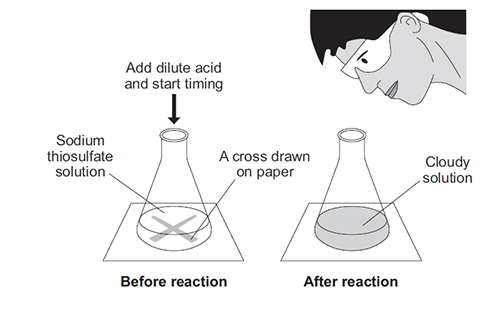
Concentration of hydrochloric acid = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ moles per dm3

**(3)**

**(Total 14 marks)**

**Q7.** A student investigated the effect of temperature on the rate of a reaction.

The picture below shows an experiment.



The student:

•        put sodium thiosulfate solution into a conical flask

•        heated the sodium thiosulfate solution to the required temperature

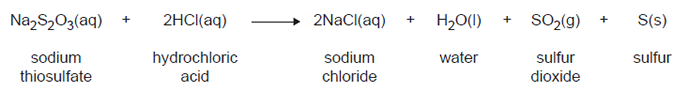
•        put the flask on a cross drawn on a piece of paper

•        added dilute hydrochloric acid and started a stopclock

•        stopped the stopclock when the cross could no longer be seen

•        repeated the experiment at different temperatures.

The equation for the reaction is:



(a)     Explain why the solution goes cloudy.

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**(2)**

(b)     Give **two** variables the student must control to make the investigation a fair test.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(c)     State the effect that increasing the temperature of the sodium thiosulfate solution has on the rate of the reaction.

Explain this effect in terms of particles and collisions.

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**(4)**

(d)     Suggest how the student should change the method to investigate the rate of reaction at 5°C.

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**(1)**

**(Total 9 marks)**

**Q8.** This question is about reversible reactions and chemical equilibrium.

(a)     Reversible reactions can reach equilibrium in a closed system.

(i)      What is meant by a closed system?

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**(1)**

(ii)     Explain why, when a reversible reaction reaches equilibrium, the reaction appears to have stopped.

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**(2)**

(b)     In the Haber process, the reaction of nitrogen with hydrogen to produce ammonia is reversible.

                                  N2(g)     +     3 H2(g)          2 NH3(g)

(i)      Name a natural resource from which hydrogen is produced.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(ii)     The Haber process uses a catalyst to speed up the reaction.

Explain how a catalyst speeds up a reaction.

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**(2)**

(iii)    What happens to the amount of ammonia produced at equilibrium if the pressure is increased? Give a reason for your answer.

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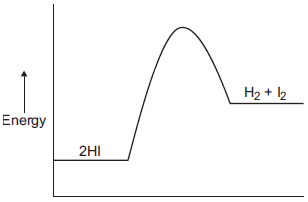
**(2)**

(c)     The decomposition of hydrogen iodide into hydrogen and iodine is reversible.

                                    2HI(g)          H2(g)     +     I2(g)

The forward reaction is endothermic.

The energy level diagram shown below is for the forward reaction.



(i)      Draw an arrow to show the activation energy on the diagram.

**(1)**

(ii)     How does the diagram show that the reaction is endothermic?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(iii)    Suggest what effect, if any, increasing the temperature will have on the amount of hydrogen iodide at equilibrium.

Give a reason for your answer.

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**(2)**

**(Total 12 marks)**

**Q1.**This question is about hydrocarbons.

The table gives information about four hydrocarbons.

The hydrocarbons are four successive members of a homologous series.

|  |  |  |
| --- | --- | --- |
| **Hydrocarbon** | **Formula** | **Boiling point in °C** |
| **A** | C4H10 | 0 |
| **B** |  | 36 |
| **C** | C6H14 | 69 |
| **D** | C7H16 | 98 |

(a)     What is the formula of hydrocarbon **B**?

Tick (✔) **one** box.

|  |  |
| --- | --- |
| C4H12 |  |
| C5H12 |  |
| C5H12 |  |
| C6H12 |  |

**(1)**

(b)     What is the simplest ratio of carbon : hydrogen atoms in a molecule of hydrocarbon **A**?

Ratio = 2 : \_\_\_\_\_\_\_

**(1)**

(c)     Which hydrocarbon is a gas at room temperature (25 °C)?

Tick (✔) **one** box.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **A** |  |  | **B** |  |  | **C** |  |  | **D** |  |

**(1)**

(d)     Which hydrocarbon is most flammable?

Tick (✔) **one** box.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **A** |  |  | **B** |  |  | **C** |  |  | **D** |  |

**(1)**

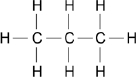
(e)     Which **two** substances are produced when a hydrocarbon **completely** combusts in air?

Tick (✔) **two** boxes.

|  |  |
| --- | --- |
| Carbon |  |
| Carbon dioxide |  |
| Hydrogen |  |
| Sulfur dioxide |  |
| Water |  |

**(2)**

The diagram shows the displayed structure of a hydrocarbon molecule.



(f)      What is the name of the hydrocarbon in the diagram above?

Tick (✔) **one** box.

|  |  |
| --- | --- |
| Butane |  |
| Ethane |  |
| Methane |  |
| Propane |  |

**(1)**

(g)     Calculate the relative formula mass (*M*r) of the hydrocarbon in the diagram above.

Relative atomic masses (*A*r): H = 1 C = 12

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Relative formula mass (*M*r) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

**(Total 9 marks)**

**Q2.** This question is about alkenes and crude oil.

(a)     Pentene is an alkene molecule containing five carbon atoms.

Complete the formula for pentene.

C \_\_\_\_\_ H \_\_\_\_\_

**(1)**

(b)     Butene is an alkene molecule containing four carbon atoms.

The diagram shows all of the atoms and some of the bonds in the displayed formula for butene.

Complete the displayed formula by adding the remaining bonds.



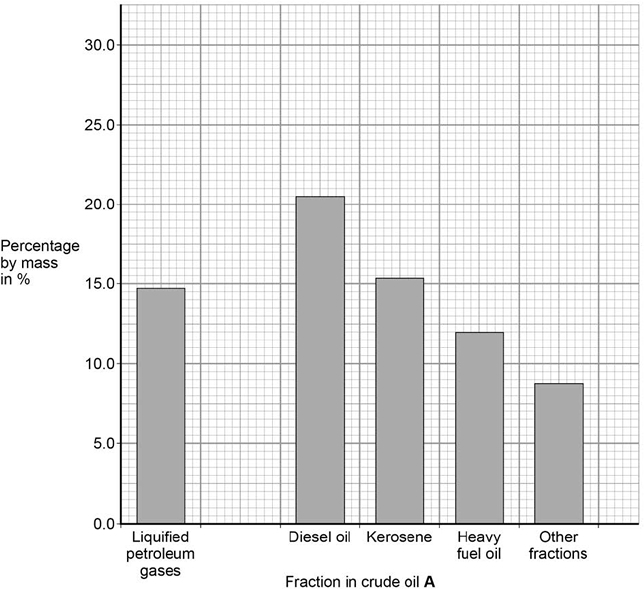
**(1)**

Pentene and butene are produced from crude oil.

The table shows the percentages of different fractions in two samples of crude oil.

|  |  |  |
| --- | --- | --- |
| **Fraction** | **Percentages by mass in %** | |
| **Crude oil A** | **Crude oil B** |
| Liquefied petroleum gases | 14.7 | 7.1 |
| Petrol | 28.6 | 11.1 |
| Diesel oil | 20.5 | 17.2 |
| Kerosene | 15.4 | 38.5 |
| Heavy fuel oil | 12.0 | 16.0 |
| Other fractions | 8.8 | 10.1 |

The graph shows the percentages of different fractions in crude oil **A**.



(c)     Plot the data for petrol in the table above on the graph.

**(1)**

(d)     What mass of crude oil **A** is needed to obtain 12 tonnes of heavy fuel oil?.

Use the table above.

|  |  |
| --- | --- |
| 10 tonnes |  |
| 100 tonnes |  |
| 1000 tonnes |  |
| 10 000 tonnes |  |

**(1)**

(e)     What mass of crude oil **A** is needed to obtain 12 tonnes of heavy fuel oil?.

Calculate the total mass of car fuel that can be produced from 2000 kg of crude oil **B**.

Use the table above.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Mass of car fuel = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ kg

**(3)**

(f)      Crude oil **B** is a better source of hydrocarbons for cracking than crude oil **A**.

Suggest why.

Use the table above.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(g)     Alkenes are obtained from crude oil using fractional distillation followed by cracking.

Explain how alkenes are produced using fractional distillation followed by cracking.

**(6)**

**(Total 14 marks)**

**Q3.**

The table below gives information about four alcohols.

|  |  |  |  |
| --- | --- | --- | --- |
| **Alcohol** | **Formula** | **Melting point  in °C** | **Boiling point  in °C** |
| Methanol | CH3OH | −94 | 65 |
| Ethanol | CH3CH2OH | −118 | 78 |
| Propanol | CH3CH2CH2OH | −129 | 97 |
| Butanol | CH3CH2CH2CH2OH | −89 | 118 |

(a)     Which alcohol in the table is liquid over the greatest temperature range?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

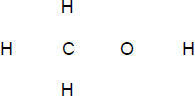
(b)     Which statement is correct?

|  |  |
| --- | --- |
| Tick **one** box. |  |
| A molecule of ethanol has 5 hydrogen atoms |  |
| Butanol has the highest boiling point |  |
| Methanol has the largest molecules |  |
| Propanol has the highest melting point |  |

**(1)**

(c)     A molecule of methanol has five single covalent bonds. Draw the missing bonds in **Figure 1** to complete the displayed formula for methanol.

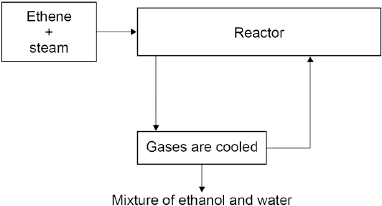
**Figure 1**

****

**(1)**

(d)     **Figure 2** shows a flow diagram of the process to produce ethanol.

**Figure 2**

****

Complete the word equation for the reaction to produce ethanol.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_   +   \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  →  ethanol

**(1)**

(e)     What happens to the unreacted ethene?

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**(1)**

(f)     Wine contains ethanol.

A bottle of wine was left open in air.

After a few days, the wine tasted of vinegar.

Vinegar is a solution of ethanoic acid in water.

Explain how oxidation causes the wine to taste of vinegar after a few days.

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**(3)**

**(Total 8 marks)**

**Q4.**

This question is about organic compounds. Hydrocarbons can be cracked to produce smaller molecules. The equation shows the reaction for a hydrocarbon, C18H38

C18H38     →   C6H14   +   C4H8   +   2 C3H6   +   C2H4

(a)     Which product of the reaction shown is an alkane?

|  |  |
| --- | --- |
| Tick **one** box. |  |
| C2H4 |  |
| C3H6 |  |
| C4H8 |  |
| C6H14 |  |

**(1)**

(b)     The table below shows the boiling point, flammability and viscosity of C18H38 compared with the other hydrocarbons shown in the equation.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Boiling point** | **Flammability** | **Viscosity** |
| **A** | highest | lowest | highest |
| **B** | highest | lowest | lowest |
| **C** | lowest | highest | highest |
| **D** | lowest | highest | lowest |

Which letter, **A**, **B**, **C** or **D**, shows how the properties of C18H38 compare with the properties of C2H4, C3H6, C4H8 and C6H14?

|  |  |
| --- | --- |
| Tick **one** box. |  |
| **A** |  |
| **B** |  |
| **C** |  |
| **D** |  |

**(1)**

(c)     The hydrocarbon C4H8 was burnt in air. Incomplete combustion occurred.

Which equation, **A**, **B**, **C** or **D**, correctly represents the incomplete combustion reaction?

**A**                 C4H8     +     4O     →     4CO       +     4H2

**B**                 C4H8     +    4O2     →     4CO      +     4H2O

**C**                 C4H8     +    6O2     →     4CO2     +     4H2O

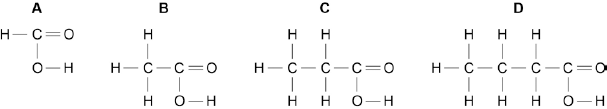
**D**                 C4H8     +     8O     →     4CO2     +     4H2

|  |  |
| --- | --- |
| Tick **one** box. |  |
| **A** |  |
| **B** |  |
| **C** |  |
| **D** |  |

**(1)**

(d)     Propanoic acid is a carboxylic acid.

Which structure, **A**, **B**, **C** or **D**, shows propanoic acid?



|  |  |
| --- | --- |
| Tick **one** box. |  |
| **A** |  |
| **B** |  |
| **C** |  |
| **D** |  |

**(1)**

(e)     Propanoic acid is formed by the oxidation of which organic compound?

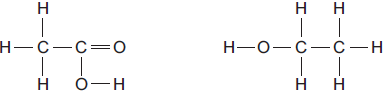
|  |  |
| --- | --- |
| Tick **one** box. |  |
| Propane |  |
| Propene |  |
| Propanol |  |
| Polyester |  |

**(1)**

**(Total 5 marks)**

**Q5.**The diagrams represent two compounds, **A** and **B**.

**Compound A**                                 **Compound B**

****

(a)     (i)      Compound **B** is an alcohol. Name compound **B**.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(ii)     Use the correct answer from the box to complete the sentence.

|  |  |  |
| --- | --- | --- |
| **burned** | **decomposed** | **oxidised** |

To form compound **A**,

compound **B** is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(iii)    Compounds **A** and **B** are both colourless liquids. A test tube contains a colourless liquid, which could be either compound **A** or compound **B**. Describe a simple **chemical** test to show which compound, **A** or **B**, is in the test tube.

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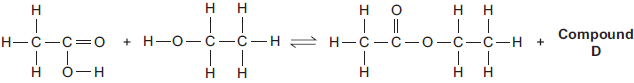
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**(2)**

(b)     Compounds **A** and **B** react to produce compound **C** and compound **D**.

**Compound A**               **Compound B**               **Compound C**

****

(i)      What is the formula of compound **D**?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(ii)     Compound **C** is an ester. Name compound **C**.

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**(1)**

(iii)    State **one** use of esters.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

**(Total 7 marks)**

**Q6.** This question is about organic compounds.

(a)     Ethanol is an alcohol. One use of ethanol is in alcoholic drinks. Give **two** other uses of ethanol.

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**(2)**

(b)     Which gas is produced when sodium reacts with ethanol?

|  |  |
| --- | --- |
| Tick () **one** box. | |
| Carbon dioxide |  |
| Carbon monoxide |  |
| Hydrogen |  |
| Oxygen |  |

**(1)**

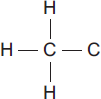
(c)     Ethanoic acid (CH3COOH) can be produced from ethanol (CH3CH2OH).

(i)      What type of reaction produces ethanoic acid from ethanol?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(ii)     Complete the displayed structure of ethanoic acid.



**(1)**

(iii)    Solutions of ethanoic acid and hydrochloric acid with the same concentration have different pH values.

Explain why the solution of ethanoic acid has a higher pH than the solution of hydrochloric acid.

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**(2)**

(d)     Ethanol and ethanoic acid react in the presence of a catalyst to form an ester.

(i)      Name the ester made from ethanol and ethanoic acid.

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**(1)**

(ii)     What type of chemical is used as a catalyst in this reaction?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(iii)    Esters are used in perfumes because they smell pleasant and are volatile.

What does volatile mean?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

**(Total 10 marks)**

**Q7.** This question is about organic compounds.

(a)     Ethanol burns in air. Use the correct answer from the box to complete the word equation for the reaction.

|  |  |  |
| --- | --- | --- |
| **carbon** | **hydrogen** | **oxygen** |

ethanol     +     \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_          carbon dioxide     +     water

**(1)**

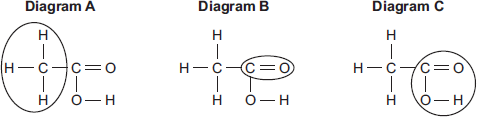
(b)     Use the correct answer from the box to complete the sentence.

|  |  |  |
| --- | --- | --- |
| **milk** | **hard water** | **vinegar** |

Ethanoic acid is in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ .

**(1)**

(c)     Ethanoic acid is a carboxylic acid. Which diagram, **A, B** or **C**, has a ring around the functional group of a carboxylic acid? Write your answer in the box.



|  |  |
| --- | --- |
| Diagram |  |

**(1)**

(d)     Ethyl propanoate is produced by reacting ethanol with propanoic acid. What type of organic compound is ethyl propanoate?

|  |  |
| --- | --- |
| Tick () **one** box. | |
| Alcohol |  |
| Carboxylic acid |  |
| Ester |  |

**(1)**

(e)     Organic compounds such as ethyl propanoate are used in perfumes.

Give **two** properties of these compounds that make them suitable for use in perfumes.

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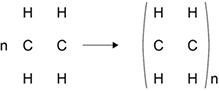
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**(2)**

**(Total 6 marks)**

**Q8.** Ethene is used to produce poly(ethene).

(a)     Draw the bonds to complete the displayed formulae of ethene and poly(ethene) in the equation.



**(2)**

(b)     Polyesters are made by a different method of polymerisation.

The equation for the reaction to produce a polyester can be represented as:



Compare the polymerisation reaction used to produce poly(ethene) with the polymerisation reaction used to produce a polyester.

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**(4)**

**(Total 6 marks)**

**Q9.** This question is about ethanol.

(a)     Ethanol can be made by fermentation of sugars from plants.

(i)      What is a suitable temperature for fermentation?

Draw a ring around the correct answer.

|  |  |  |
| --- | --- | --- |
| **0 °C** | **25 °C** | **450 °C** |

**(1)**

(ii)     Fermentation produces a dilute solution of ethanol in water.

Name the process used to obtain ethanol from this dilute solution.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(b)     Ethanol made by fermentation can be used as a biofuel.

(i)      Explain why increasing the use of biofuels may cause food shortages.

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**(2)**

(ii)     Explain why burning biofuels contributes less to climate change than burning fossil fuels.

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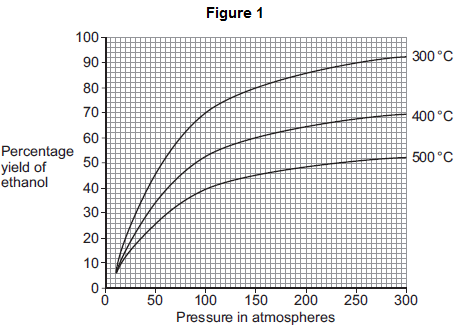
**(2)**

(c)     **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate**.

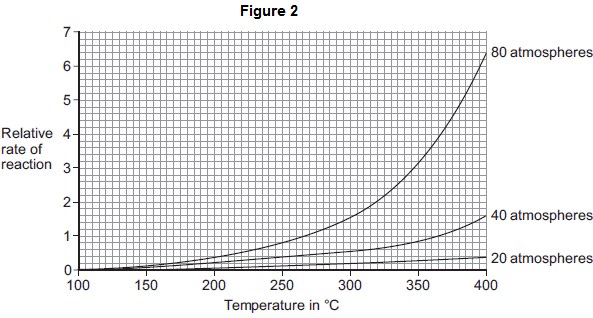
Ethanol can also be made by reacting ethene with steam in the presence of a catalyst.

                        C2H4(g) + H2O(g)  C2H5OH(g)

**Figure 1** shows how the percentage yield of ethanol changes as the pressure is changed at three different temperatures.



**Figure 2** shows how the rate of reaction changes as the temperature changes at three different pressures.



In one process for the reaction of ethene with steam the conditions are:

•        300 °C

•        65 atmospheres

•        a catalyst.

Use the information in **Figure 1** and **Figure 2**, and your own knowledge, to justify this choice of conditions.

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**(6)**

**(Total 12 marks)**

**Q10.** This question is about polymers.

(a)     The polymer polyvinyl chloride (PVC) is non-biodegradable. Give **one** problem caused by non-biodegradable polymers.

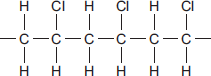
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**(1)**

(b)     **Figure 1** shows a short section of a PVC molecule.

**Figure 1**

****

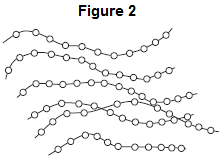
PVC is produced from a monomer that contains two carbon atoms.

Complete the structure of the monomer.

|  |  |
| --- | --- |
| **C** | **C** |

**(2)**

(c)     **Figure 2** represents a few short chains of PVC molecules.



Explain why PVC softens and melts when heated.

Use **Figure 2** and your knowledge of structure and bonding to help you to answer the question.

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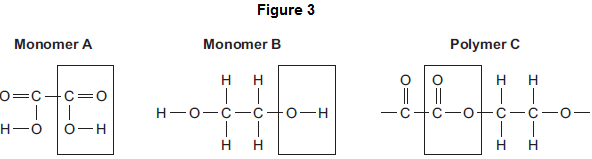
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**(3)**

(d)     Monomer **A** and monomer **B** react to form polymer **C**.

The displayed structures of monomer **A**, monomer **B** and a short section of polymer **C** are shown in **Figure 3**. The functional group of each structure is shown in a box.



Complete the **Table** below below by writing the names of the functional groups for monomer **A** and polymer **C**.

**Table**

|  |  |
| --- | --- |
|  | **Name of functional group** |
| Monomer **A** | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| Monomer **B** | alcohol |
| Polymer **C** | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

**(2)**

**(Total 8 marks)**

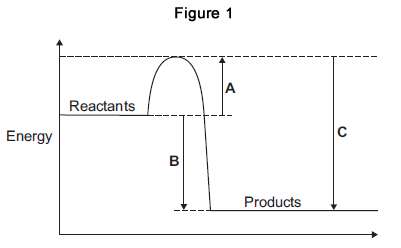
**Q11.** This question is about energy changes in chemical reactions.

(a)     Complete the word equation for the combustion of hydrogen.

hydrogen          +          oxygen          →          \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(b)     **Figure 1** shows a simple energy level diagram.



(i)      Which arrow, **A**, **B** or **C**, shows the activation energy?

|  |  |
| --- | --- |
| Tick (✔) **one** box. |  |
| **A** |  |
| **B** |  |
| **C** |  |

**(1)**

(ii)     What type of reaction is shown by the energy level diagram in **Figure 1**?

Give a reason for your answer.

Type of reaction \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Reason \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(iii)    For a reaction, the value of **A** is 1370 kJ and **C** is 3230 kJ.

Calculate the value of **B**.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

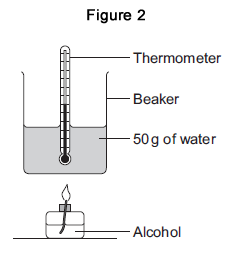
**B** = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ kJ

**(1)**

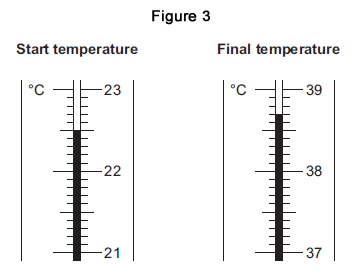
(c)     Alcohols are used as fuels.

A group of students investigated the amount of energy released when different alcohols are burned.

The students used the apparatus shown in **Figure 2**.



(i)      **Figure 3** shows the start temperature and the final temperature of the water.



Write the start temperature and the final temperature of the water in **Table 1**.

Work out the increase in temperature to complete **Table 1**.

|  |  |
| --- | --- |
| **Table 1** | |
| Start temperature of the water in °C |  |
| Final temperature of the water in °C |  |
| Increase in temperature in °C |  |

**(3)**

(ii)     The students worked out the heat energy released by burning 1 g of each alcohol.

The students used the equation: Look at **Figure 2**. What is the value of m?

                Heat energy released = m × 4.2 × increase in temperature

m = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

**(1)**

(iii)     **Table 2** shows the students’ results.

|  |  |  |
| --- | --- | --- |
| **Table 2** | | |
| **Name of alcohol** | **Number of carbon atoms in one molecule of alcohol** | **Heat energy released when 1 g of alcohol is burned in kJ** |
| Methanol | 1 | 11.4 |
| Ethanol | 2 | 13.5 |
| Propanol | 3 | 20.1 |
| Butanol | 4 | 16.8 |
| Pentanol | 5 | 17.2 |

Which value of heat energy released is anomalous?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(iv)     Look at **Table 2**. What is the relationship between the number of carbon atoms in one molecule of alcohol and the heat energy released when 1 g of the alcohol is burned?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(v)     The value in a data book for the amount of heat energy released when 1 g of butanol is burned completely is 36.2 kJ. Suggest two reasons why the students’ result for butanol is lower than the data book value.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

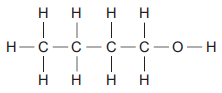
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2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(vi)     The displayed structure of butanol is:



What is the functional group of the alcohol?

|  |  |
| --- | --- |
| Tick (✔) **one** box. |  |
| –– C –– C |  |
| –– C –– H |  |
| –– O –– H |  |

**(1)**

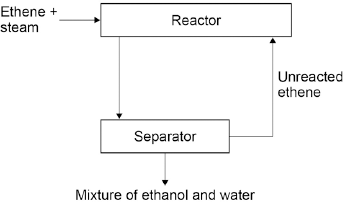
**(Total 14 marks)**

**Q12.** In industry ethanol is produced by the reaction of ethene and steam at 300°C and 60 atmospheres pressure using a catalyst.

The equation for the reaction is:

    C2H4 (g) + H2O (g)         C2H5OH (g)

The figure below shows a flow diagram of the process.



(a)     Why does the mixture from the separator contain ethanol and water?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(b)     The forward reaction is exothermic. Use Le Chatelier’s Principle to predict the effect of increasing temperature on the amount of ethanol produced at equilibrium. Give a reason for your prediction.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(c)     Explain how increasing the pressure of the reactants will affect the amount of ethanol produced at equilibrium.

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**(2)**

**(Total 5 marks)**

**Q1.** Burgundy Mixture is a formulation used to kill fungi on grapevines.

It is made by mixing two compounds, **A** and **B**. The ratio by mass of **A** : **B** in the mixture is 1 : 8

(a)     Calculate the mass of A needed in a mixture containing 125 g of **B**.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Mass of **A** = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ g

**(2)**

Scientists test a solution of compound **A**. The table shows their results.

|  |  |
| --- | --- |
| **Test** | **Result** |
| Add sodium hydroxide solution | Blue precipitate |
| Add dilute hydrochloric acid and barium chloride solution | White precipitate |

(b)     Which **two** ions are in compound **A**? Choose the answers from the box.

|  |  |  |
| --- | --- | --- |
| **bromide** | **chloride** | **copper** |
| **iron(II)** | **iron(III)** | **sulfate** |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ions and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ions

**(2)**

(c)     The scientists think that compound **B** is sodium carbonate.

Describe how the scientists can test a solution of **B** to see if sodium ions are present.

Give the result of the test if sodium ions are present.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(d)     Describe how the scientists can test a solution of **B** to see if carbonate ions are present.

Give the result of the test if carbonate ions are present.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(3)**

**(Total 9 marks)**

**Q2.** A student investigated a food colouring using paper chromatography.This is the method used.

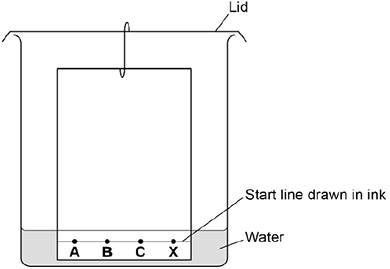
1.       Put a spot of food colouring **X** on the start line.

2.       Put spots of three separate dyes, **A**, **B** and **C**, on the start line.

3.       Place the bottom of the paper in water and leave it for several minutes.

(a)     **Figure 1** shows the apparatus the student used.

**Figure 1**

****

Give **two** mistakes the student made in setting up the experiment.

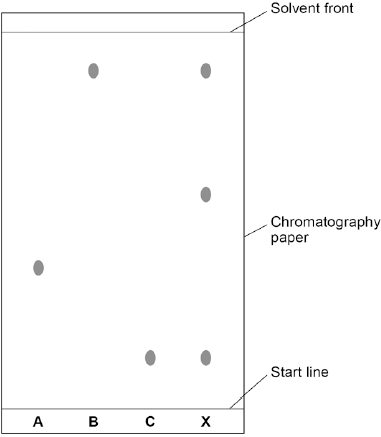
|  |  |
| --- | --- |
| Tick **two** boxes. |  |
| The lid was on the beaker. |  |
| The paper did not touch the bottom of the beaker. |  |
| The spots were too small. |  |
| The start line was drawn in ink. |  |
| The water level was above the spots. |  |

**(2)**

(b)     Another student set the experiment up correctly.

**Figure 2** shows the student’s results.

**Figure 2**

****

How many dyes were in **X**? Tick **one** box.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1** |  |  | **3** |  |  | **4** |  |  | **6** |  |

**(1)**

(c)     Which dye, **A**, **B** or **C**, is **not** in **X**?

|  |  |
| --- | --- |
| Write your answer in the box. |  |

**(1)**

(d)     Use **Figure 2** to complete the table below. Calculate the value for Rf for dye **A**.

|  |  |
| --- | --- |
|  | **Distance in mm** |
| Distance moved by dye **A** | \_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| Distance from start line to solvent front | \_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

Use the equation: Give your answer to two significant figures.



\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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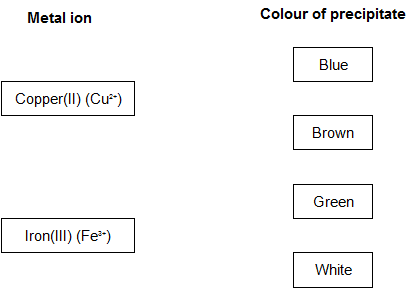
Rf value = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(5)**

**(Total 9 marks)**

**Q3.** This question is about chemical tests.

1. Solutions of copper(II) ions and iron(III) ions produce coloured precipitates with sodium hydroxide solution. Draw **one** line from each metal ion to the colour of the precipitate it produces.



**(2)**

(b)     Sodium hydroxide solution was added to a solution containing ions of a metal. A white precipitate was produced. The white precipitate dissolved in excess sodium hydroxide solution. Use the correct answer from the box to complete the sentence.

|  |  |  |
| --- | --- | --- |
| **aluminium** | **magnesium** | **potassium** |

The ions in the solution were ions of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ .

**(1)**

(c)     Low sodium salt contains sodium chloride and potassium chloride. A student used a flame test on low sodium salt.

(i)      What is the colour produced by sodium ions in a flame test?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(ii)     What is the colour produced by potassium ions in a flame test?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(iii)    Why is it **not** possible to tell from the flame test that both ions are present in low sodium salt?

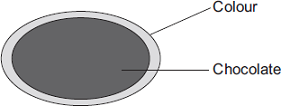
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**(1)**

**(Total 6 marks)**

**Q4.** Colours are used to coat some chocolate sweets.Some of these colours are given E-numbers.



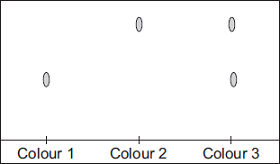
(a)     Use the correct word from the box to complete the sentence.

|  |  |  |
| --- | --- | --- |
| **additive** | **element** | **fuel** |

An E-number is used to identify a permitted food \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(b)     Chromatography was used to compare three of the colours used to coat the chocolate sweets.



What do these results tell you about these three colours?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(3)**

**(Total 4 marks)**

**Q5.** A student investigated food dyes using paper chromatography.This is the method used.

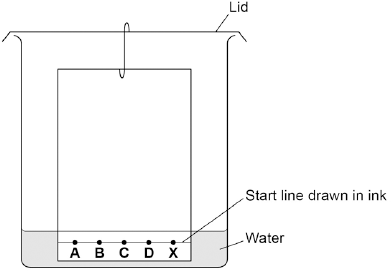
1.       Put a spot of food colouring **X** on the start line.

2.       Put spots of four separate dyes, **A**, **B**, **C** and **D**, on the start line.

3.       Place the bottom of the paper in water and leave it for several minutes.

**Figure 1** shows the apparatus the student used.

**Figure 1**

****

(a)     Write down **two** mistakes the student made in setting up the experiment and explain what problems one of the mistakes would cause.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

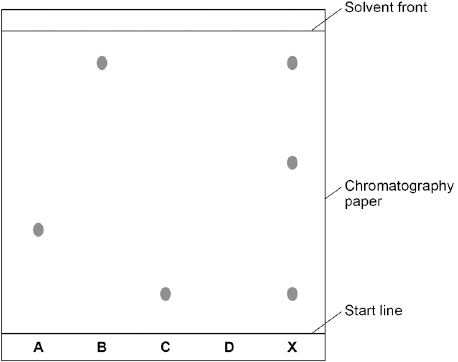
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**(2)**

(b)     Another student set up the apparatus correctly. **Figure 2** shows the student’s results. The result for dye **D** is not shown.

**Figure 2**

****

Calculate the Rf value of dye **A** Give your answer to two significant figures.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Rf value = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(3)**

(c)     Dye **D** has an Rf value of 0.80. Calculate the distance that dye **D** moved on the chromatography paper.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Distance moved by dye **D** = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(d)     Explain how the different dyes in **X** are separated by paper chromatography.

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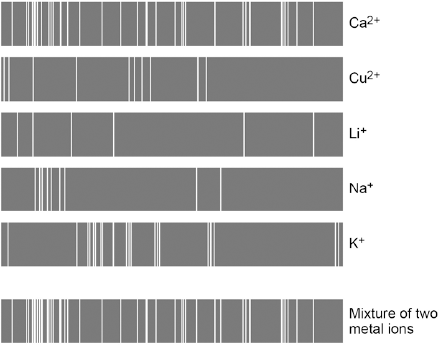
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**(4)**

(e)     Flame emission spectroscopy can be used to analyse metal ions in solution.

**Figure 3** gives the flame emission spectra of five metal ions, and of a mixture of two metal ions.

**Figure 3**

****

Use the spectra to identify the **two** metal ions in the mixture.

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**(2)**

(f)     Explain why a flame test could **not** be used to identify the two metal ions in the mixture.

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**(2)**

(g)     Two students tested a green compound **X**.

The students added water to compound **X**.

Compound **X** did not dissolve.

The students then added a solution of ethanoic acid to compound **X**.

A gas was produced which turned limewater milky.

Student **A** concluded that compound **X** was sodium carbonate.

Student **B** concluded that compound **X** was copper chloride.

Which student, if any, was correct?

Explain your reasoning.

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**(4)**

**(Total 18 marks)**

**Q6.** Ethene can be identified using instrumental methods.

(i)      Name **one** instrumental method used to identify elements or compounds.

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**(1)**

(ii)      Give **one** advantage of using instrumental methods compared with chemical tests.

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**(1)**

**(Total 2 marks)**

**Q7.** Alums are salts. They have been used since ancient times in dyeing and medicine and still have many uses today.Three alums are shown in the table:

|  |  |
| --- | --- |
| **Name** | **Ions present** |
| Ammonium alum | NH4+     Al3+     SO42– |
| Potassium alum | K+       Al3+     SO42– |
| Sodium alum | Na+       Al3+     SO42– |

A student tested these alums to show which ions were present.

(a)     The student did a flame test on these alums. A sample of each alum was held on a wire in a colourless flame.

In (a)(i) and (a)(ii) use the correct word from the box to complete each sentence.

|  |  |  |  |
| --- | --- | --- | --- |
| **blue** | **lilac** | **yellow** | **green** |

(i)      Sodium ions give a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ flame. **(1)**

(ii)     Potassium ions give a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ flame. **(1)**

(iii)    Draw a ring around the correct answer to complete the sentence.

|  |  |
| --- | --- |
|  | density. |
| The wire used in a flame test should have a high | electrical conductivity. |
|  | melting point. |

**(1)**

(b)     Draw a ring around the correct word to complete the sentences.

(i)      The student tested a solution of each salt for sulfate ions (SO42– ).

|  |  |  |
| --- | --- | --- |
|  | barium chloride |  |
| The student added dilute hydrochloric acid and | nitric acid | solution and |
|  | silver nitrate |  |

|  |  |  |
| --- | --- | --- |
|  | gas |  |
| a white | liquid | was formed. |
|  | solid |  |

**(2)**

(ii)     The student tested a solution of each salt for aluminium ions (Al3+ ).

|  |  |  |
| --- | --- | --- |
|  | green |  |
| The student added sodium hydroxide solution and a | red | precipitate |
|  | white |  |

was formed. When excess sodium hydroxide solution was added, the

|  |  |
| --- | --- |
|  | boiled. |
| precipitate | condensed. |
|  | dissolved. |

**(2)**

**(Total 7 marks)**

**Q8.** Limestone is used as a building material. Acid rain erodes limestone.

(a)     Limestone contains calcium carbonate.The symbol equation for the reaction of calcium carbonate with hydrochloric acid is shown.

  CaCO3(s)   +   2HCl(aq)    →   CaCl2(aq)   +   H2O(l)   +   CO2(g)

Describe a test to show that carbon dioxide is produced in this reaction. Give the result of the test.

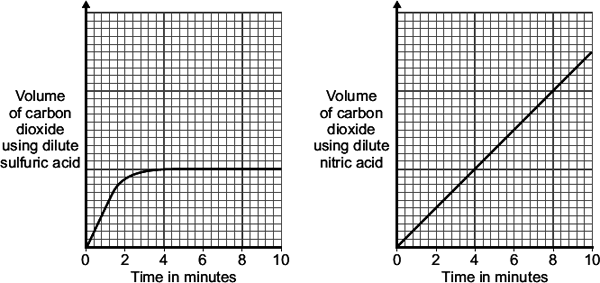
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**(2)**

(b)     Gases from vehicle exhausts produce sulfuric acid and nitric acid. A student investigated the reaction of these two acids with calcium carbonate (limestone).The type of acid was changed but all other variables were kept the same.The student measured the volume of carbon dioxide produced each minute for a total of 10 minutes. He did this first for the reaction between dilute sulfuric acid and a cube of calcium carbonate (limestone).  
The student repeated the experiment using dilute nitric acid in place of the dilute sulfuric acid.The results are shown below.



(i)      State **two** variables that must be kept the same for this investigation.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(i)      Reacting calcium carbonate with sulfuric acid gave different results to nitric acid.

The symbol equations for the reaction of calcium carbonate with sulfuric acid and with nitric acid are shown below.

CaCO3(s)   +   H2SO4(aq)   →   CaSO4(s)       +     H2O(l)   +   CO2(g)

CaCO3(s)   +   2HNO3(aq)   →   Ca(NO3)2(aq)   +   H2O(l)   +   CO2(g)

Describe how the results for sulfuric acid are different **and** use the symbol equations to explain this difference.

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**(3)**

**(Total 7 marks)**

**Q9.**

Four bottles of chemicals made in the 1880s were found recently in a cupboard during a Health and Safety inspection at Lovell Laboratories.

|  |  |
| --- | --- |
| Sodium carbonate | Sodium chloride |
| Sodium nitrate | Sodium sulfate |

The chemical names are shown below each bottle.

(a)     You are provided with the following reagents:

•        aluminium powder

•        barium chloride solution acidified with dilute hydrochloric acid

•        dilute hydrochloric acid

•        silver nitrate solution acidified with dilute nitric acid

•        sodium hydroxide solution.

•        limewater

•        red litmus paper

(i)      Describe tests that you could use to show that these chemicals are correctly named.

In each case give the reagent(s) you would use **and** state the result.

Test and result for carbonate ions:

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Test and result for chloride ions:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Test and result for nitrate ions:

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Test and result for sulfate ions:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(4)**

(ii)     Suggest why a flame test would **not** distinguish between these four chemicals.

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**(1)**

(b)     Instrumental methods of analysis linked to computers can be used to identify chemicals.

Give **two** advantages of using instrumental methods of analysis.

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**(2)**

**(Total 7 marks)**

**Q10.** This question is about chemical analysis.

(a)     A student has solutions of three compounds, **X, Y** and **Z**.

The student uses tests to identify the ions in the three compounds.

The student records the results of the tests in the table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Test** | | | |
| **Compound** | **Flame test** | **Add sodium hydroxide solution** | **Add hydrochloric acid and barium chloride solution** | **Add nitric acid and silver nitrate solution** |
| **X** | no colour | green precipitate | white precipitate | no reaction |
| **Y** | yellow flame | no reaction | no reaction | yellow precipitate |
| **Z** | no colour | brown precipitate | no reaction | cream precipitate |

Identify the **two** ions present in each compound, **X, Y** and **Z**.

**X** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Y** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Z** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(3)**

(b)     A chemist needs to find the concentration of a solution of barium hydroxide.

Barium hydroxide solution is an alkali. The chemist could find the concentration of the barium hydroxide solution using two different methods.

**Method 1**

•        An excess of sodium sulfate solution is added to 25 cm3 of the barium hydroxide solution. A precipitate of barium sulfate is formed.

•        The precipitate of barium sulfate is filtered, dried and weighed.

•        The concentration of the barium hydroxide solution is calculated from the mass of barium sulfate produced.

**Method 2**

•        25 cm3 of the barium hydroxide solution is titrated with hydrochloric acid of known concentration.

•        The concentration of the barium hydroxide solution is calculated from the result of the titration.

Compare the advantages and disadvantages of the two methods.

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**(5)**

**(Total 8 marks)**

**Q11.** The colours of fireworks are produced by chemicals.



(a)     Information about four chemicals is given in the table. Complete the table below.

|  |  |
| --- | --- |
| **Chemical** | **Colour produced in firework** |
| barium chloride | green |
| \_\_\_\_\_\_\_\_\_\_\_\_\_ carbonate | crimson |
| sodium nitrate | \_\_\_\_\_\_\_\_\_\_\_\_\_ |
| calcium sulfate | red |

**(2)**

(b)     Describe a test to show that barium chloride solution contains chloride ions. Give the result of the test.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(c)     A student did two tests on a solution of compound **X**.

**Test 1**   
Sodium hydroxide solution was added.   
A blue precipitate was formed.

**Test 2**   
Dilute hydrochloric acid was added.   
Barium chloride solution was then added.   
A white precipitate was formed.

The student concluded that compound **X** is iron(II) sulfate.

Is the student’s conclusion correct? Explain your answer.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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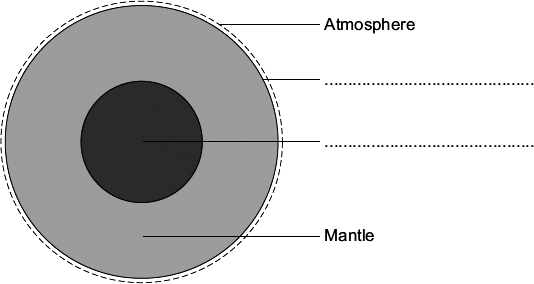
**(3)**

**(Total 7 marks)**

**Q1.** The Earth has a layered structure and is surrounded by an atmosphere.

(a)     The diagram shows the layers of the Earth.

Complete the labels on the diagram.

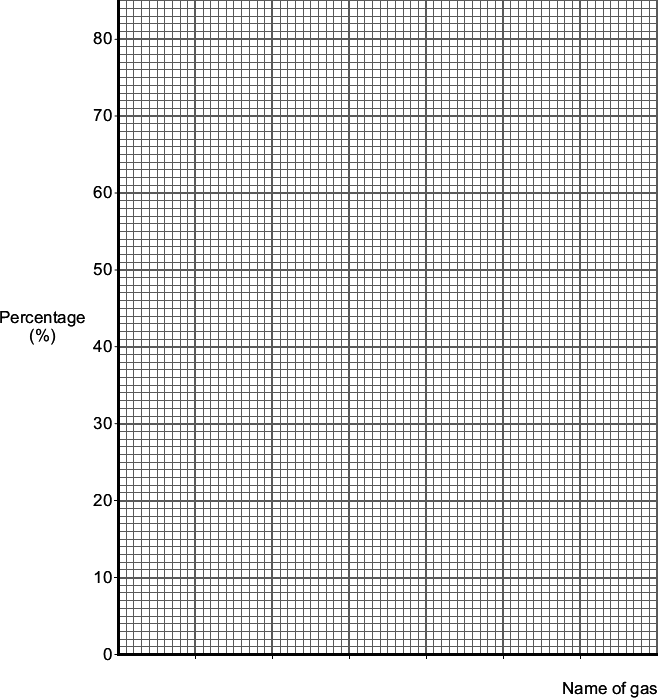


**(2)**

(b)     The data in the table shows the percentages of the gases in the Earth’s atmosphere.

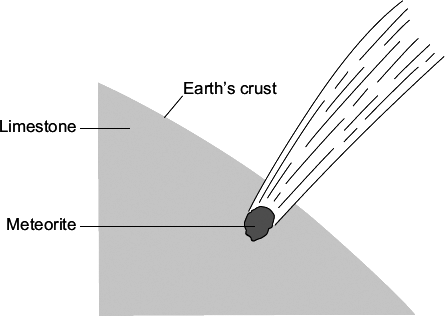
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| **Name of gas** | **Percentage (%) of gas** |
| Nitrogen | 78 |
| Oxygen | 21 |
| Other gases | 1 |

Present the data in the table on the grid below.



**(3)**

(c)     Millions of years ago a large meteorite hit the Earth.  
The meteorite heated limestone in the Earth’s crust to a very high temperature.  
The heat caused calcium carbonate in the limestone to release large amounts of carbon dioxide.



Draw a ring round the correct answer to complete each sentence.

|  |  |  |
| --- | --- | --- |
|  |  | decomposed. |
| (i) | Carbon dioxide was released because the calcium carbonate was | evaporated. |
|  |  | reduced. |

**(1)**

|  |  |  |
| --- | --- | --- |
|  |  | acid rain. |
| (ii) | More carbon dioxide in the Earth’s atmosphere causes | global dimming. |
|  |  | global warming. |

**(1)**

**(Total 7 marks)**

**Q2.** Coal is used as a fuel in power stations.

The table shows the percentage of carbon and sulfur in four different coal samples.

|  |  |  |
| --- | --- | --- |
| **Sample** | **Percentage (%) by mass in coal** | |
| **Carbon** | **Sulfur** |
| **A** | 22.1 | 0.4 |
| **B** | 46.8 | 0.6 |
| **C** | 66.3 | 0.9 |
| **D** | 92.0 | 0.7 |

(a)     Sulfur produces a gas that causes acid rain. Name the gas.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(b)     Give **one** environmental effect caused by acid rain.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(c)     Which coal sample produces the most acid rain from 1 kg of coal? Use the table above.

Give a reason for your answer.

Sample \_\_\_\_\_\_\_\_\_\_

Reason \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(d)     Calculate the mass of coal sample **A** that would produce the same amount of carbon dioxide as 1 kg of coal sample **C**.

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Mass of coal sample **A** = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ kg

**(2)**

(e)     Incomplete combustion of coal can produce carbon monoxide.

Carbon monoxide is a toxic gas.

Give **two** reasons why people may be unaware of the presence of carbon monoxide.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

**(Total 8 marks)**

**Q3.** This question is about life, the Earth and its atmosphere.

(a)     There are many theories about how life was formed on Earth.

Suggest **one** reason why there are many theories.

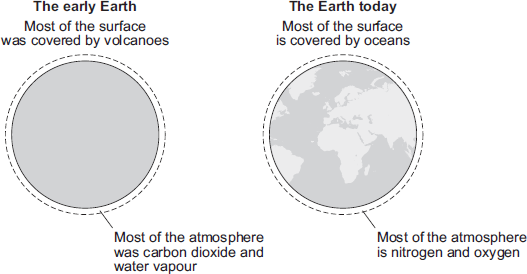
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**(1)**

(b)     **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

This Earth and its atmosphere today are not like the early Earth and its atmosphere.



Describe and explain how the surface of the early Earth and its atmosphere have changed to form the surface of the Earth and its atmosphere today.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(6)**

**(Total 7 marks)**

**Q4.** Scientists study the atmosphere on planets and moons in the Solar System to understand how the Earth’s atmosphere has changed.

(a)     Millions of years ago the Earth’s atmosphere was probably just like that of Mars today.

The table shows data about the atmosphere of Mars and Earth today.

|  |  |  |  |
| --- | --- | --- | --- |
| **Mars today** | | **Earth today** | |
| nitrogen | 3% | nitrogen | 78% |
| oxygen | trace | oxygen | 21% |
| water | trace | water | trace |
| Carbon dioxide | 95% | Carbon dioxide | trace |
| Average surface temperature −23°C | | Average surface temperature 15°C | |

The percentages of some gases in the Earth’s atmosphere of millions of years ago have changed to the percentages in the Earth’s atmosphere today.

For **two** of these gases describe how the percentages have changed **and** suggest what caused this change.

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**(2)**

(b)     Titan is the largest moon of the planet Saturn.  
Titan has an atmosphere that contains mainly nitrogen.   
Methane is the other main gas.

|  |  |  |
| --- | --- | --- |
| **Main gases in Titan's atmosphere** | **Percentage (%)** | **Boiling point in °C** |
| Nitrogen | 95 | −196 |
| Methane | 5 | −164 |
| Average surface temperature −178°C | | |

When it rains on Titan, it rains methane! Use the information above and your knowledge and understanding to explain why.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(c)     Ultraviolet radiation from the Sun produces simple alkenes, such as ethene (C2H4) and propene (C3H6) from methane in Titan’s atmosphere.

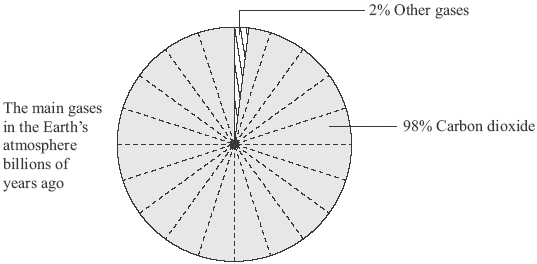
State the general formula for alkenes.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

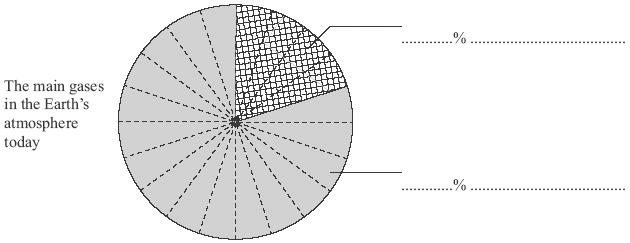
**(1)**

**(Total 5 marks)**

**Q5.** Life on Earth would not exist without the atmosphere. Billions of years ago the composition of the Earth’s atmosphere was very different from the composition today.



(a)     Label the pie chart below to show the percentages and names of the two main gases in the Earth’s atmosphere today.



**(2)**

(b)     There is evidence that the composition of the Earth’s atmosphere is still changing. One possible reason is that many power stations generate electricity by burning fossil fuels such as coal, oil or natural gas. Sulfur dioxide, SO2, is produced when coal burns in air.

(i)      What environmental problem does sulfur dioxide cause?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(ii)     How could this environmental problem be reduced in coal-fired power stations?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(iii)     Gas-fired power stations burn methane, CH4, in air.

Complete the word equation for this reaction.

methane  +  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  →  carbon dioxide    \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(c)     Excess carbon dioxide should be prevented from entering the atmosphere. Explain why.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

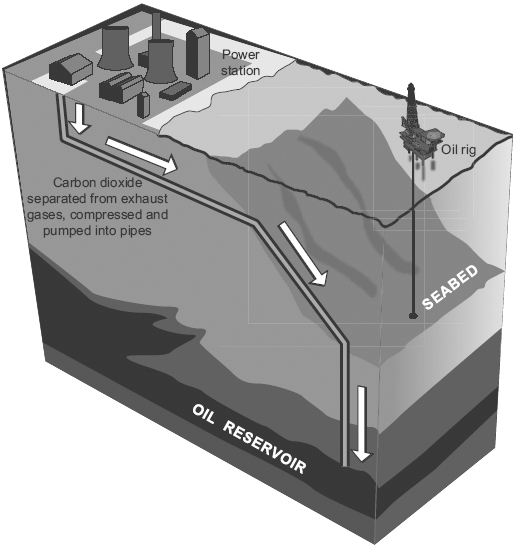
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**(2)**

(d)     Carbon dioxide is produced when fossil fuels burn in power stations. The diagram represents one idea to prevent excess carbon dioxide from entering the atmosphere.



          Use the diagram to explain how carbon dioxide can be prevented from entering the atmosphere.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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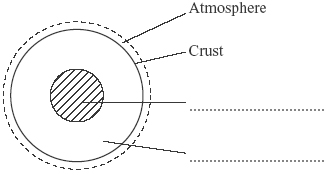
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**(2)**

**(Total 10 marks)**

**Q6.** The Earth is shaped like a ball and is surrounded by an atmosphere.

(a)     The diagram shows the layered structure of the Earth.

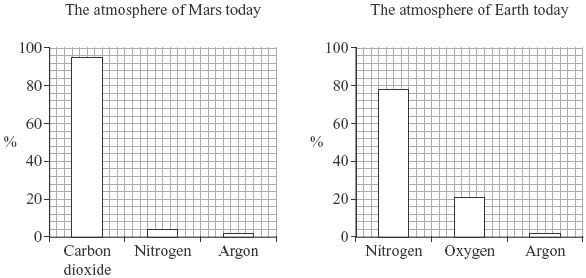


Choose words from the box to complete the labels on the diagram.

|  |  |  |
| --- | --- | --- |
| **core** | **mantle** | **plate** |

**(2)**

(b)     Some theories suggest that the Earth’s early atmosphere was like the atmosphere of Mars today. The bar charts show the three most common gases in each atmosphere today.



(i)      Use the bar charts to complete the sentence by writing in the correct gases.

In the atmosphere of Mars today there is mainly \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

and no \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ .

**(2)**

(ii)     Use the bar charts to complete the sentence by writing in the correct number.

These theories suggest that there was about \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ % nitrogen in the Earth’s early atmosphere.

**(1)**

(iii)     The atmosphere of the Earth today has much more nitrogen than in the early atmosphere. Denitrifying bacteria released most of this nitrogen into the atmosphere.

There are other differences between the Earth’s early atmosphere and the atmosphere of the Earth today. Use the bar charts to describe and explain **two** of these other differences.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(3)**

**(Total 8 marks)**

**Q7.** Greenhouse gases affect the temperature of the Earth.

(a)     Which gas is a greenhouse gas?

|  |  |
| --- | --- |
| Tick **one** box. |  |
| Argon |  |
| Methane |  |
| Nitrogen |  |
| Oxygen |  |

**(1)**

(b)     An increase in global temperature will cause climate change.

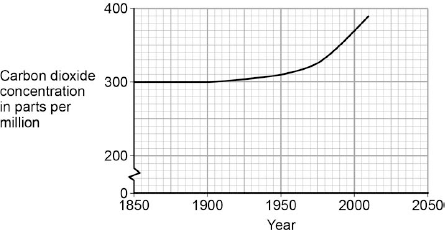
What is **one** possible effect of climate change?

|  |  |
| --- | --- |
| Tick **one** box. |  |
| Deforestation |  |
| Global dimming |  |
| Sea levels rising |  |
| Volcanic activity |  |

**(1)**

(c)     Carbon dioxide is also a greenhouse gas.

The figure below shows how the concentration of carbon dioxide in the atmosphere has changed since 1850.



Which process is the reason for the change in carbon dioxide concentration shown on the figure above?

|  |  |
| --- | --- |
| Tick **one** box. |  |
| Burning of fossil fuels |  |
| Carbon capture |  |
| Formation of sedimentary rocks |  |
| Photosynthesis |  |

**(1)**

(d)     Give **three** conclusions that can be made from the figure above.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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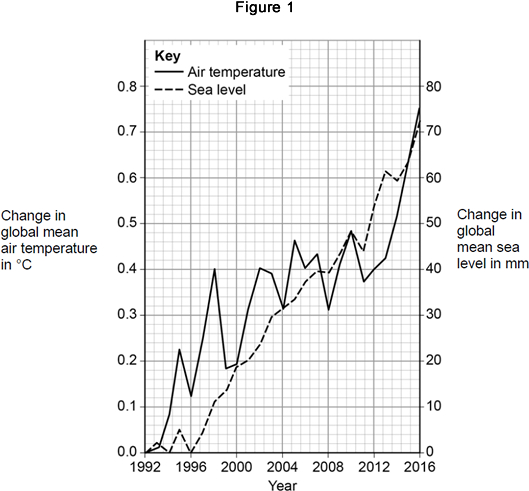
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**(3)**

**(Total 6 marks)**

**Q8.** This question is about climate change.

**Figure 1** shows the changes in the global mean air temperature and global mean sea level from 1992 to 2016.



(a)     Calculate the mean yearly increase in sea level between 1992 and 2016. Use **Figure 1**.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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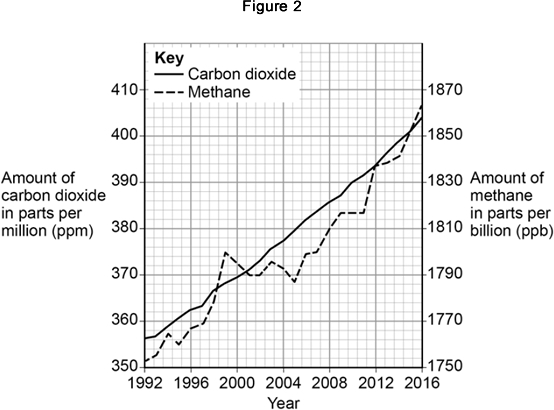
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Mean yearly increase in sea level = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ mm / year

**(2)**

Most scientists think carbon dioxide and methane are a cause of global climate change.

**Figure 2** shows the amounts of these gases in the atmosphere from 1992 to 2016.



(b)     Describe the changes in **Figure 1** and in **Figure 2**.

Explain how these changes have taken place.

**(6)**

(c)     The data was collected by a single scientific group.

Give **two** reasons why more evidence is needed to support any conclusions made by this scientific group.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

**(Total 10 marks)**

**Q9.** This question is about copper.

(a)     Copper can be extracted by smelting copper-rich ores in a furnace.

The equation for one of the reactions in the smelting process is:

                 Cu2S(s) + O2(g)  2 Cu(s) + SO2(g)

Explain why there would be an environmental problem if sulfur dioxide gas escaped into the atmosphere.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

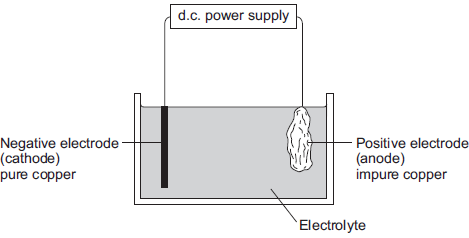
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**(2)**

(b)     The impure copper produced by smelting is purified by electrolysis, as shown below.



Copper atoms are oxidised at the positive electrode to Cu2+ ions, as shown in the half equation.

                                    Cu(s)  Cu2+(aq) + 2e−

(i)      How does the half equation show that copper atoms are oxidised?

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**(1)**

(ii)     The Cu2+ ions are attracted to the negative electrode, where they are reduced to produce copper atoms.

Write a balanced half equation for the reaction at the negative electrode.

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**(1)**

(iii)    Suggest a suitable electrolyte for the electrolysis.

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**(1)**

(c)     Copper metal is used in electrical appliances.

Describe the bonding in a metal, and explain why metals conduct electricity.

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**(4)**

(d)     Soil near copper mines is often contaminated with low percentages of copper compounds.

Phytomining is a new way to extract copper compounds from soil. Describe how copper compounds are extracted by phytomining.

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**(3)**

(e)     A compound in a copper ore has the following percentage composition by mass:

                            55.6% copper, 16.4% iron, 28.0% sulfur.

Calculate the empirical formula of the compound.

Relative atomic masses (*A*r): S = 32; Fe = 56; Cu = 63.5

You must show all of your working.

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Empirical formula = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(4)**

**(Total 16 marks)**

**Q10.** Sulfur is a non-metal.

Sulfur burns in the air to produce sulfur dioxide, SO2

(a)     Why is it important that sulfur dioxide is **not** released into the atmosphere?

Tick (✔) **one** box.

|  |  |
| --- | --- |
| Sulfur dioxide causes acid rain. |  |
| Sulfur dioxide causes global dimming. |  |
| Sulfur dioxide causes global warming. |  |

**(1)**

(b)     Sulfur dioxide dissolves in water.

What colour is universal indicator in a solution of sulfur dioxide?  
Give a reason for your answer.

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**(2)**

(c)     Sulfur dioxide is a gas at room temperature. The bonding in sulfur dioxide is covalent.

Explain, in terms of its structure and bonding, why sulfur dioxide has a low boiling point.

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**(3)**

(d)     *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

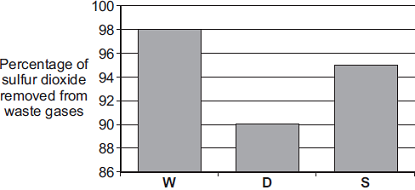
Sulfur dioxide is produced when fossil fuels are burned. It is important that sulfur dioxide is not released into the atmosphere. Three of the methods used to remove sulfur dioxide from gases produced when fossil fuels are burned are:

•        wet gas desulfurisation (**W**)

•        dry gas desulfurisation (**D**)

•        seawater gas desulfurisation (**S**).

Information about the three methods is given in the bar chart and in **Table 1** and **Table 2**.

  
                        Method of removing sulfur dioxide

**Table 1**

|  |  |  |
| --- | --- | --- |
| **Method** | **Material used** | **How material is obtained** |
| **W** | Calcium carbonate, CaCO3 | Quarrying |
| **D** | Calcium oxide, CaO | Thermal decomposition of calcium carbonate: CaCO3    CaO  +  CO2 |
| **S** | Seawater | From the sea |

**Table 2**

|  |  |
| --- | --- |
| **Method** | **What is done with waste material** |
| **W** | Solid waste is sold for use in buildings. Carbon dioxide is released into the atmosphere. |
| **D** | Solid waste is sent to landfill. |
| **S** | Liquid waste is returned to the sea. |

Evaluate the three methods of removing sulfur dioxide from waste gases. Compare the three methods and give a justified conclusion.

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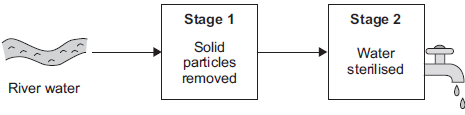
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**(6)**

**(Total 12 marks)**

**Q1.** This question is about water.River water needs to be treated before it is safe to drink.

(a)     The diagram shows two stages of the treatment of river water.



(i)      What is the name of the process used to remove solid particles in **Stage 1**?

Tick () **one** box.

|  |  |
| --- | --- |
| Crystallisation |  |
| Fermentation |  |
| Filtration |  |

**(1)**

(ii)     What is added in **Stage 2** to sterilise the water? Tick () **one** box.

|  |  |
| --- | --- |
| Chlorine |  |
| Fluoride |  |
| Potassium |  |

**(1)**

(b)     Toxic substances in river water are removed by adding very small amounts of iron oxide nanoparticles.

(i)      How is the size of nanoparticles different from normal-sized particles?

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**(1)**

(ii)     Nanoparticles are needed in only very small amounts. Suggest why.

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**(1)**

(c)     In certain areas of the UK, tap water contains aluminium ions. What would you **see** when sodium hydroxide solution is added drop by drop to tap water containing aluminium ions?

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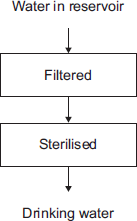
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**(2)**

**(Total 6 marks)**

**Q2.** This question is about drinking water.

(a)     The flow diagram below shows how water is made suitable for drinking.



(i)      What is removed when the water is filtered?

|  |  |
| --- | --- |
| Tick () **one** box. | |
| Gases |  |
| Liquids |  |
| Solids |  |

**(1)**

(ii)     What is used to sterilise the water?

|  |  |
| --- | --- |
| Tick () **one** box. | |
| Carbon |  |
| Chlorine |  |
| Sodium chloride |  |

**(1)**

(iii)    Why is the water sterilised?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(b)     Water can be purified by distillation. Drinking water is **not** usually purified by distillation because distillation is expensive.

Complete the sentence.

Distillation is expensive because it requires a lot of

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**(1)**

(c)     Why do some water companies add fluoride to drinking water?

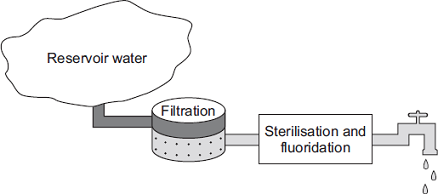
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**(1)**

**(Total 5 marks)**

**Q3.** The diagram shows three stages in the treatment of reservoir water.



(a)     (i)      What is separated from the reservoir water during filtration? Tick (✔) **one** box.

|  |  |
| --- | --- |
| Bacteria |  |
| Dissolved nitrates |  |
| Solids |  |

**(1)**

(ii)     What is added to sterilise the water? Tick (✔) **one** box.

|  |  |
| --- | --- |
| Calcium |  |
| Chlorine |  |
| Magnesium |  |

**(1)**

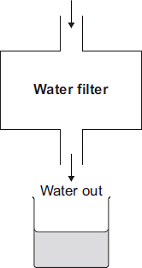
(iii)    State **one** advantage of adding fluoride to drinking water.

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**(1)**

(b)     The diagram shows a water filter used in the home.

Water in  


A student collected a sample of water from the filter. The student could show that the filtered water contains dissolved salts without using a chemical test. Describe how.

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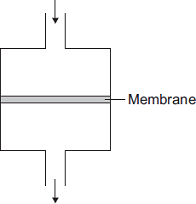
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**(2)**

(c)     Seawater is forced through a membrane to make drinking water.

Seawater  
               
Drinking water

Suggest why water molecules can pass through the membrane, but sodium ions and chloride ions cannot.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

**(Total 6 marks)**

**Q4.** Iron is extracted from its ore.

(a)     Iron ore is quarried.

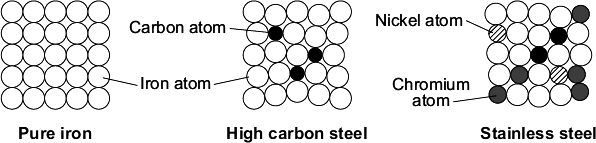


Quarrying iron ore has impacts that cause environmental problems. Tick () **two** impacts of quarrying that cause environmental problems.

|  |  |
| --- | --- |
| **Impact of quarrying** | **Tick ()** |
| puts off tourists |  |
| causes dust pollution |  |
| increases jobs |  |
| increases traffic |  |

**(2)**

(b)     The diagrams represent the atoms in iron and the atoms in two alloys of iron.



Use the diagrams to help you to answer these questions.

(i)      Complete the sentence.

Pure iron does **not** have many uses because \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(ii)     Stainless steel is more expensive than pure iron. Suggest why.

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**(1)**

(c)     Draw a ring around the correct answer to complete each sentence.

|  |  |  |
| --- | --- | --- |
|  |  | a compound. |
| (i) | Pure iron is | an element. |
|  |  | a mixture. |

**(1)**

|  |  |  |
| --- | --- | --- |
|  |  | brittle. |
| (ii) | High carbon steel is used for a drill bit because it is | easily bent. |
|  |  | hard. |

**(1)**

|  |  |  |
| --- | --- | --- |
|  |  | contains three different atoms. |
| (iii) | Stainless steel is used to make cutlery because it | melts at a very high temperature. |
|  |  | is resistant to corrosion. |

**(1)**

**(Total 7 marks)**

**Q5.** Copper is a transition metal.

(a)     (i)      Where is copper in the periodic table?

|  |  |
| --- | --- |
| Tick () **one** box. | |
| in the central block |  |
| in Group 1 |  |
| in the noble gas group |  |

**(1)**

(ii)     What is a property of copper?

|  |  |
| --- | --- |
| Tick () **one** box. | |
| breaks easily |  |
| conducts electricity |  |
| does not conduct heat |  |

**(1)**

(b)     Copper ores are quarried by digging large holes in the ground, as shown in **Figure 1**.



Give **two** reasons why quarrying is bad for the environment.

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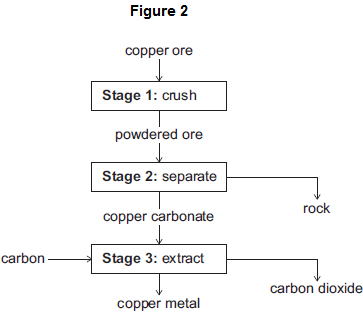
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**(2)**

(c)     Some copper ores contain only 2% copper. Most of the ore is rock that is not needed. In one ore, the main compound is copper carbonate (CuCO3).

**Figure 2** shows the stages used in the extraction of copper from this ore.



(i)      Why is **Stage 2** important?

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**(1)**

(ii)     The equation for the reaction in **Stage 3** is:

2 CuCO3     +     C          2 Cu     +     3 CO2

From the symbol equation, a company calculated that 247 tonnes of copper carbonate are needed to produce 127 tonnes of copper and 132 tonnes of carbon dioxide are released. Calculate the mass of carbon needed to make 127 tonnes of copper.



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**(2)**

(iii)    Suggest **one** reason why it is important for the company to calculate the mass of reactants in **Stage 3**.

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**(1)**

**(Total 8 marks)**

**Q6.** Cans for food and drinks are made from steel or aluminium.The main metal in steel is iron.



(a)     Iron is extracted by heating a mixture of iron oxide and carbon in a blast furnace.

(i)      Name this type of reaction.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

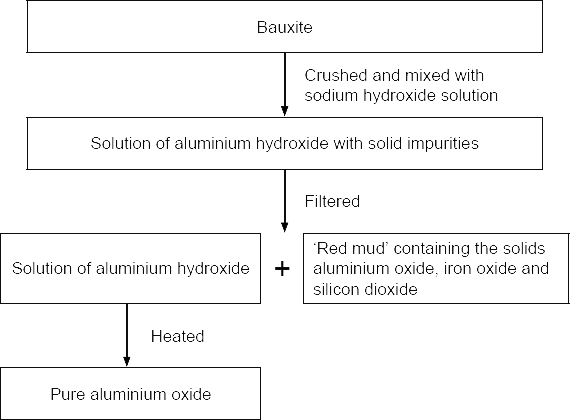
**(1)**

(ii)     Balance the symbol equation for this reaction.

2Fe2O3 + \_\_\_\_\_\_ C → \_\_\_\_\_\_ Fe + \_\_\_\_\_\_ CO2

**(1)**

(b)     Aluminium ore, bauxite, contains aluminium oxide, iron oxide and silicon dioxide. Aluminium is extracted by electrolysis of aluminium oxide.



The 'red mud' which is dumped in very large ponds contains:

|  |  |
| --- | --- |
| **Name of solid** | **Percentage (%)** |
| Aluminium oxide | 10 |
| Iron oxide | 65 |
| Silicon dioxide | 25 |

(i)      100 tonnes of bauxite produced 50 tonnes of pure aluminium oxide and 50 tonnes of 'red mud'. What percentage of aluminium oxide did the bauxite contain?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

                                                  Answer = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ %

**(1)**

(ii)     Apart from the solids shown in the table, name **one** other substance that would be in the 'red mud'.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(iii)    The purification of the aluminium oxide is usually done near to the bauxite quarries.

Suggest **one** reason why.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(c)     Aluminium is used to make many things including cans.

During one year in the USA:

•        100 billion aluminium cans were sold

•        55 billion aluminium cans were recycled.

Give **one** environmental impact of recycling aluminium cans and **one** ethical or social impact of recycling aluminium cans.

Environmental \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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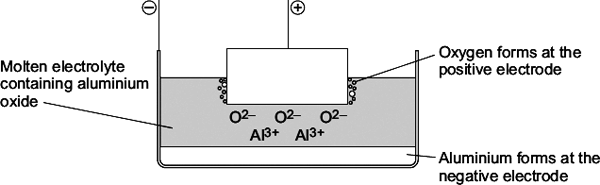
Ethical or social \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

**(Total 7 marks)**

**Q7.**The diagram represents an electrolysis cell for extracting aluminium.  
The current will only flow when the electrolyte is molten.



(a)     The electrolyte is aluminium oxide mixed with another substance.

(i)      What is the name of the other substance in the electrolyte?

Draw a ring around the correct answer.

|  |  |  |
| --- | --- | --- |
| **cryolite** | **rock salt** | **limestone** |

**(1)**

(ii)     Draw a ring around the correct answer to complete the sentence.

|  |  |
| --- | --- |
|  | condense the aluminium oxide. |
| This other substance is added to | lower the melting point of the aluminium oxide. |
|  | raise the boiling point of the aluminium oxide. |

**(1)**

(b)     (i)     Oxide ions (O2−) move to the positive electrode. Explain why.

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**(2)**

(ii)     Oxygen is formed at the positive electrode. The oxygen then forms carbon dioxide.

The equation for the reaction is shown below.

                     C    +    O2       →       CO2

Complete the sentence.

The name of the element which reacts with oxygen is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(iii)     The positive electrode gets smaller. Suggest why.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(c)     Aluminium is used in an alloy with magnesium to make drinks cans.

The diagrams show the arrangement of atoms in pure aluminium and in the alloy.

|  |  |
| --- | --- |
|  |  |

The alloy is harder than pure aluminium. Explain why. Use the diagrams to help you.

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**(2)**

**(Total 8 marks)**

**Q8.**

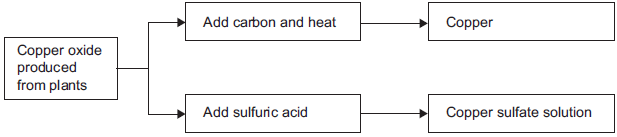
Where copper ore has been mined there are areas of land that contain very low percentages of copper compounds. One way to extract the copper is to grow plants on the land.

The plants absorb copper compounds through their roots.

The plants are burned to produce copper oxide.

The copper oxide produced from plants can be reacted to produce copper or copper sulfate solution, as shown in **Figure 1**.

**Figure 1**

****

(a)     Draw a ring around the correct answer to complete each sentence.

|  |  |  |
| --- | --- | --- |
| (i) | Copper ores contain enough copper to make extraction of the metal | carbon neutral.  economical.  reversible. |

**(1)**

|  |  |  |
| --- | --- | --- |
| (ii) | Using plants to extract metals is called | photosynthesis.  phytomining.  polymerisation. |

**(1)**

|  |  |  |
| --- | --- | --- |
| (iii) | Copper oxide reacts with carbon to produce copper and | carbon dioxide.  oxygen.  sulfur dioxide. |

**(1)**

(b)     Copper is produced from copper sulfate solution by displacement using iron or by electrolysis.

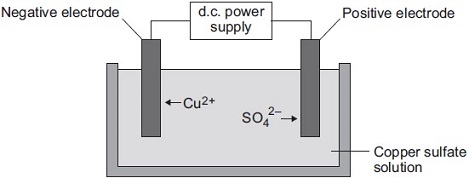
(i)      Complete the word equation.

copper sulfate    +    iron        \_\_\_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_\_\_

**(2)**

(ii)     **Figure 2** shows the electrolysis of copper sulfate solution.

**Figure 2**

****

Why do copper ions go to the negative electrode?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(c)     Suggest **two** reasons why copper should **not** be disposed of in landfill sites.

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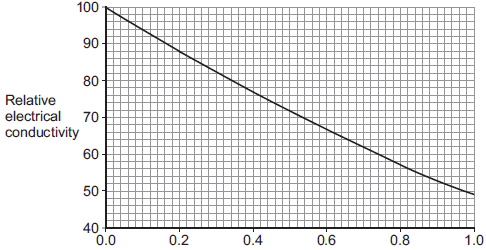
**(2)**

**(Total 8 marks)**

**Q9.** This question is about copper.

(a)     Most of the copper extracted is used in electric circuits.

The figure below shows how impurities change the electrical conductivity of copper.

  
                Percentage of impurities in copper

Copper extracted by smelting is about 99% pure. The 99% pure copper produced by smelting is purified to 99.9999% pure copper by electrolysis. Use values from the graph to explain why copper is purified to 99.9999%.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(b)     **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Read the information in the box.

|  |
| --- |
| **Copper extraction**  World demand for copper for the year 2011 was about 20 million tonnes.  World reserves of copper are estimated to be 700 million tonnes.  Most of the copper used is obtained from copper ores, which are mined.  The copper ore chalcopyrite is heated in a furnace to produce copper sulfide, CuS  The furnace is heated by burning fossil fuels.  Air is then blown through the hot copper sulfide, to produce copper and sulfur dioxide.  CuS + O2 → Cu + SO2 |

A scientist made the statement: ‘Copper should be recycled’.

Use the information in the box and your own knowledge and understanding to justify the scientist’s statement.

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**(6)**

(c)     Phytomining is used to obtain copper from land that contains very low percentages of copper compounds. Describe how copper compounds are obtained by phytomining.

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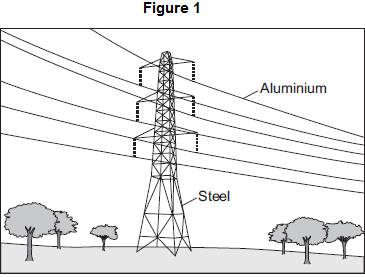
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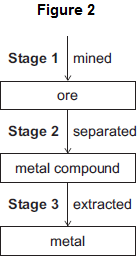
**(3)**

**(Total 11 marks)**

**Q10.** This question is about metals. **Figure 1** shows the metals used to make pylons and the wires of overhead cables.



(a)     An ore contains a metal compound. A metal is extracted from its ore in three main stages, as shown in **Figure 2**.



Explain why **Stage 2** needs to be done.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(b)     Cast iron from a blast furnace contains 96% iron and 4% carbon.

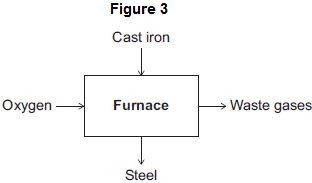
(i)      Cast iron is not suitable for the manufacture of pylons. Give **one** reason why.

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**(1)**

(ii)     Most cast iron is converted into steel, as shown in **Figure 3**.



Describe how cast iron is converted into steel.

Use **Figure 3** to help you to answer this question.

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**(2)**

(c)     Aluminium and copper are good conductors of electricity.

(i)      State **one** property that makes aluminium more suitable than copper for overhead cables.

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**(1)**

(ii)     How can you tell that copper is a transition metal and aluminium is **not** a transition metal from the position of each metal in the periodic table?

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**(2)**

(iii)    Copper can be extracted from solutions of copper salts by adding iron. Explain why.

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**(2)**

**(Total 10 marks)**

**Using our Resources**

**(GCSE CHEM ONLY) (Chemistry Paper 2)**

**Q1.** The Haber Process is used to produce ammonia from nitrogen and hydrogen.The equation for the reaction is:

N2  +  3H2  ⇌  2NH3

(a)     An ammonia molecule has the formula NH3

How many atoms are there in one molecule of ammonia? Tick (✔) **one** box.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 |  |  | 3 |  |  | 4 |  |  | 6 |  |

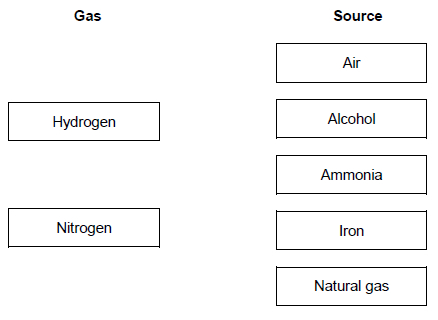
**(1)**

(b)     What does the symbol ⇌ mean?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

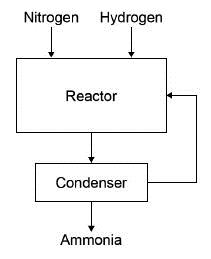
**(1)**

(c)     Draw **one** line from each gas to the source of that gas.



**(2)**

The diagram shows the Haber process.



A mixture of ammonia, hydrogen and nitrogen gases leave the reactor. **Table 1** shows the boiling points of the gases.

|  |  |
| --- | --- |
| **Table 1** | |
| **Gas** | **Boiling point in °C** |
| Ammonia | – 33 |
| Nitrogen | – 196 |
| Hydrogen | – 253 |

(d)     The mixture is cooled to a temperature at which **only** the ammonia condenses to a liquid.

Which temperature could be used? Tick (✔) **one** box.

|  |  |
| --- | --- |
| − 20 °C |  |
| − 40 °C |  |
| − 200 °C |  |
| − 260 °C |  |

**(1)**

(e)     What happens to the unreacted nitrogen? Tick (✔) **one** box.

|  |  |
| --- | --- |
| Collected and sold |  |
| Recycled to the reactor |  |
| Released into the air |  |
| Used as a catalyst |  |

**(1)**

Ammonia from the Haber process can be used to produce fertilisers.

**Table 2** gives information about two compounds used in fertilisers.

|  |  |  |
| --- | --- | --- |
| **Table 2** | | |
| **Fertiliser** | **Compound** | **Cost in £ / kg** |
| A | Potassium chloride | 0.24 |
| B | Diammonium phosphate | 0.35 |

(f)      What type of bonding is present in potassium chloride? Tick (✔) **one** box.

|  |  |
| --- | --- |
| Covalent |  |
| Ionic |  |
| Metallic |  |

**(1)**

(g)     Diammonium phosphate has the chemical formula (NH4)2HPO4

Which **two** elements in (NH4)2HPO4 improve agricultural productivity? Tick (✔) **two** boxes.

|  |  |
| --- | --- |
| Chlorine |  |
| Hydrogen |  |
| Nitrogen |  |
| Oxygen |  |
| Phosphorus |  |

A farmer uses fertilisers **A** and **B** on a field with an area of 0.05 km2

**(2)**

(h)     50 kg of fertiliser A will cover an area of 0.01 km2 Calculate the cost of fertilising a field with an area of 0.05 km2 with fertiliser **A**.Use **Table 2**.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Cost = £ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

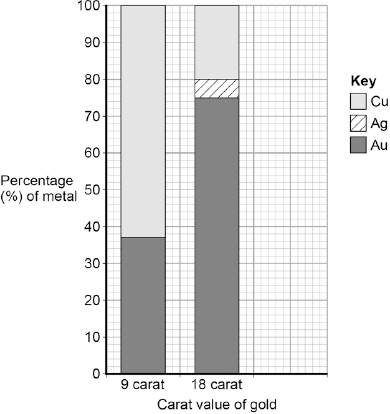
(i)      Fertiliser **B** is more expensive than fertiliser **A**. Suggest why the farmer uses **both** fertilisers.

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**(1)**

**(Total 12 marks)**

**Q2.** Gold is mixed with other metals to make jewellery.The figure below shows the composition of different carat values of gold.



(a)     What is the percentage of gold in 12 carat gold? Tick **one** box.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **12 %** |  |  | **30 %** |  |  | **50 %** |  |  | **80 %** |  |

**(1)**

(b)     Give the percentage of silver in 18 carat gold.

Use the figure above to answer this question.

Percentage = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ %

**(1)**

(c)     Suggest **two** reasons why 9 carat gold is often used instead of pure gold to make jewellery.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

**(Total 4 marks)**

**Q3.** (a)     PEX is a material that is used as an alternative to copper for hot water pipes.  
PEX is made from poly(ethene).

(i)      Describe how ethene forms poly(ethene).

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**(2)**

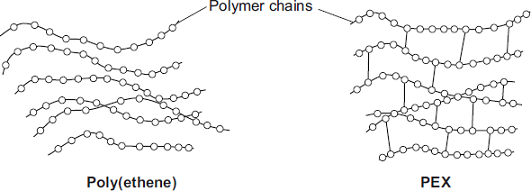
(ii)     PEX is a shape memory polymer. What property does a shape memory polymer have?

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**(1)**

(iii)    The simplified structures of poly(ethene) and PEX are shown.



Poly(ethene) is a thermoplastic that softens easily when heated.  
Suggest and explain how the structure of PEX changes this property.

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**(3)**

(b)     Copper is a suitable material to use for hot water pipes. PEX is now used as an alternative material for hot water pipes. Copper is extracted from its ore by a series of processes.

1        The low-grade copper ore is powdered and concentrated.

2        The concentrated powdered copper ore is blown into a furnace with air to produce impure, molten copper. (This furnace is heated to 1100 °C using a hydrocarbon fuel.)

3        Oxygen is blown into the impure, molten copper to remove any sulfur. The molten copper is cast into rectangular slabs.

4        The final purification of copper is done by electrolysis.

PEX is made from crude oil by a series of processes:

•        fractional distillation of crude oil

•        cracking of naphtha fraction

•        polymerisation of ethene

•        conversion of poly(ethene) into PEX.

Use the information above and your knowledge and understanding to suggest possible environmental advantages of using PEX instead of copper for hot water pipes.

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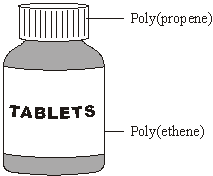
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**(4)**

**(Total 10 marks)**

**Q4.** Tablet containers are often made from two different polymers.



(a)     Ethene, C2H4, and propene, C3H6, can be made from crude oil.

(i)      Complete the following sentence.

Ethene and propene are called hydrocarbons because they are made up of

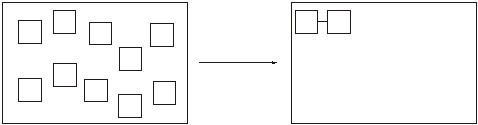
carbon and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ atoms only.

**(1)**

(ii)     Ethene molecules are used to form poly(ethene) molecules.

Complete the diagram to show the poly(ethene) molecule.

**Ethene molecules**                                              **Poly(ethene) molecule**

****

**(2)**

(b)     The tablet containers could be disposed of in a landfill site or could be recycled.

(i)      Suggest **two** reasons why disposing of the tablet containers in a landfill site could cause problems.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(ii)     Suggest **one** reason why recycling the tablet containers would be difficult.

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**(1)**

**(Total 6 marks)**

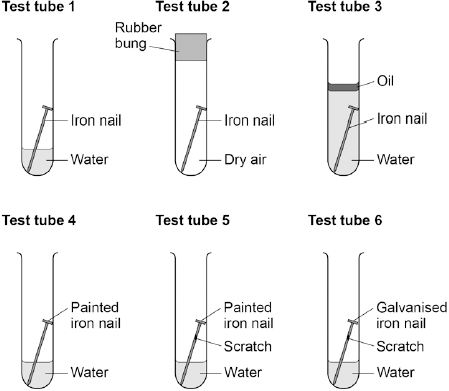
**Q5.** The figure below shows six test tubes a student set up to investigate the rusting of iron.

This is the method used for each test tube.

1.      Measure the mass of the nail using a balance.

2.      Leave the nail in the test tube for 6 days.

3.      Measure the mass of the nail after 6 days.



The table below shows the student’s measurements.

|  |  |  |
| --- | --- | --- |
| **Test tube** | **Mass of nail in g** | **Mass of nail after 6 days in g** |
| **1** | 8.45 | 8.91 |
| **2** | 8.46 | 8.46 |
| **3** | 8.51 | 8.51 |
| **4** | 9.65 | 9.65 |
| **5** | 9.37 | 9.45 |
| **6** | 9.79 | 9.79 |

(a)     What is the resolution of the balance the student used?

|  |  |
| --- | --- |
| Tick **one** box. |  |
| 1 × 10−3 g |  |
| 1 × 10−2 g |  |
| 1 × 10−1 g |  |
| 1 × 102 g |  |

**(1)**

(b)     Calculate the difference in percentage increase in mass after 6 days of the nail in test tube **1** and the nail in test tube **5**. Give your answer to **three** significant figures.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Difference in percentage increase in mass = \_\_\_\_\_\_\_\_\_\_ %

**(4)**

(c)     Use the results of the student’s investigations to draw conclusions about the factors affecting the rusting of iron. Include an evaluation of the effectiveness of different coatings at preventing the rusting of iron.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(6)**

(d)     Rust is hydrated iron(III) oxide. Complete the word equation for the reaction.

\_\_\_\_\_\_\_\_\_\_  +  \_\_\_\_\_\_\_\_\_\_   +   \_\_\_\_\_\_\_\_\_\_   →   hydrated iron(III) oxide

**(2)**

**(Total 13 marks)**

**Q6.** Gold and gold ions are used as catalysts.

(a)     An atom of gold is represented as:

             197   
       Au   
        79

Complete the sentences.

The atomic number of gold is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The number of electrons in an atom of gold is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(b)     Scientists have found that gold nanoparticles are very good catalysts. Draw a ring around the correct answer to complete the sentence.

|  |  |  |
| --- | --- | --- |
|  | hundred |  |
| A gold nanoparticle contains a few | thousand | atoms. |
|  | million |  |

**(1)**

(c)     The formation of a gold ion (Au3+) from a gold atom (Au) is shown in the symbol equation.

                Au    →    Au3+ + 3e–

(i)      Complete the sentence.

The particles lost when a gold atom becomes a gold ion

are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(ii)     Draw a ring around the correct answer to complete the sentence.

|  |  |
| --- | --- |
|  | one. |
| The number of these particles lost when a gold atom becomes a gold ion is | two. |
|  | three. |

**(1)**

(d)     Gold ions are used as a catalyst in the reaction to make chloroethene. How does a catalyst help a reaction?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

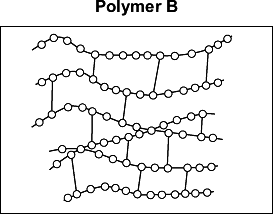
(e)     Chloroethene can react to make a thermosoftening polymer.

(i)      Draw a ring around the correct answer to complete the sentence.

|  |  |
| --- | --- |
|  | dissolve. |
| When heated, a thermosoftening polymer will | melt. |
|  | solidify. |

**(1)**

(ii)     Polymer **B** is a different type of polymer. The diagram shows the structure of polymer **B**.



How can you tell from the diagram that polymer **B** is **not** thermosoftening?

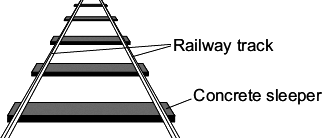
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**(1)**

**(Total 8 marks)**

**Q7.**In the UK, railway sleepers are often made from concrete.

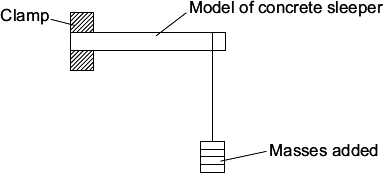


A scientist was asked to find the best concrete mixture to use so that railway sleepers would not break easily. The scientist made:

•        a mould to make small models of concrete sleepers

•        concrete mixtures using crushed rock, sand, cement and water

•        the equipment shown to add 0.1 kg masses until the model sleeper broke.



The scientist’s results are shown in the table.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Concrete mixture in % by volume** | | | **Total mass added to break the model sleeper in kg** | | | |
| **Cement** | **Sand** | **Crushed rock** | **Test 1** | **Test 2** | **Test 3** | **Mean** |
| 10 | 70 | 20 | 1.1 | 1.3 | 1.2 | 1.2 |
| 20 | 60 | 20 | 2.6 | 2.5 | 2.4 |  |
| 30 | 50 | 20 | 3.3 | 3.3 | 3.3 | 3.3 |
| 40 | 40 | 20 | 3.8 | 4.0 | 3.3 | 3.9 |
| 50 | 30 | 20 | 4.5 | 4.2 | 4.3 | 4.3 |

(a)     (i)      Calculate the mean total mass added to break the model sleeper that has 20% cement by volume.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

                                                                           Mean = \_\_\_\_\_\_\_\_\_\_\_\_\_\_ kg

**(1)**

(ii)     Choose **one** result in the table that the scientist should check and test again.

Result: % cement by volume \_\_\_\_\_\_\_\_\_\_\_\_ Test number \_\_\_\_\_\_\_\_\_\_\_\_

Explain why you chose this result.

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**(2)**

(iii)    What is the relationship between the total mass to break the model sleeper and the percentage (%) of cement by volume in the concrete mixture?

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**(1)**

(iv)     Suggest **one** other variable that the scientist should have recorded in the table of results.

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**(1)**

(b)     The scientist thought that full-size railway sleepers should be made from 30% cement,  
50% sand and 20% crushed rock.

What other information about these three materials is needed before the scientist recommends using this mixture to make a full-size railway sleeper?

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**(2)**

**(Total 7 marks)**

**Q8.** Iron will rust in damp air.

(a)     Iron reacts with water and oxygen to produce rust.

(i)      As iron rusts there is a colour change.

Draw a ring around the correct answer to complete the sentence.

During the reaction iron changes from grey to

**blue                brown                green**

**(1)**

(ii)     Rust is hydrated iron oxide.

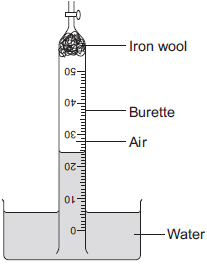
Write a word equation for the reaction of iron with oxygen and water.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(b)     A student set up the apparatus shown in **Figure 1**.

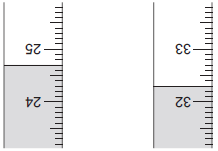
**Figure 1**

****

The student left the apparatus for a few days. The water level in the burette slowly went up and then stopped rising. **Figure 2** shows the water level in the burette at the start of the experiment and after a few days.

**Figure 2**

**At start                 After a few days**

****

(i)      Complete the table below to show the reading on the burette after a few days.

|  |  |
| --- | --- |
| Burette reading at start | 24.7 cm3 |
| Burette reading after a few days | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_cm3 |

**(1)**

(ii)     Calculate the volume of oxygen used up in the reaction.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Volume = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cm3

**(1)**

(iii)    The percentage of air that is oxygen can be calculated using the equation:

percentage of air that is oxygen =  × 100

The student **cannot** use his results to calculate the correct percentage of air that is oxygen. Explain why.

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**(2)**

(c)     A student investigated the rusting of an iron nail at different temperatures. This is the method the student used:

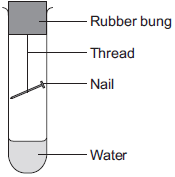
•        measure the mass of a nail

•        set up apparatus as shown in **Figure 3**

•        leave for 3 days

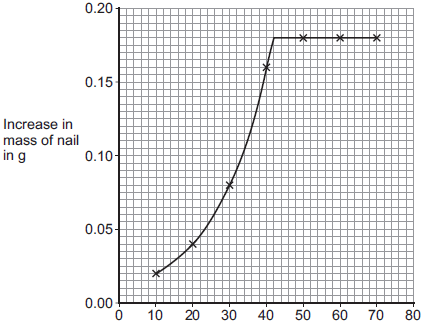
•        measure the mass of the rusted nail.

**Figure 3**

****

The student repeated the experiment at different temperatures using a new, identical, nail each time. The student’s results are shown on the graph in **Figure 4**.

**Figure 4**

****                        Temperature in °C

(i)      Why does the mass of the nail increase when it rusts?

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**(1)**

(ii)     Use the graph to describe the relationship between the temperature and the increase in mass of the nail.

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**(3)**

(iii)    The increase in mass of the nail after 3 days is a measure of the rate of rusting.

The student’s graph does **not** correctly show how increasing the temperature above 42 °C changes the rate of rusting. How could the experiment be changed to show the effect of temperatures above 42 °C on the rate of rusting?

Give a reason for your answer.

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**(2)**

**(Total 12 marks)**

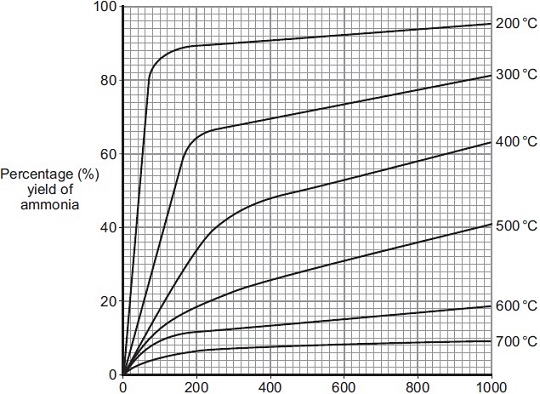
**Q9.** In 1909 Fritz Haber invented a process to produce ammonia from nitrogen and hydrogen.

(a)     Complete and balance the chemical equation for the production of ammonia from nitrogen and hydrogen.

N2      +      3 H2            \_\_\_\_\_\_\_\_\_\_

**(2)**

(b)     The figure below shows how the equilibrium yield of ammonia changes with pressure at different temperatures.

   
                    Pressure in atmospheres

(i)      Use the information in given in the figure to complete the sentence.

The temperature on the graph that gives the highest yield of ammonia is

\_\_\_\_\_\_\_\_\_ °C.

**(1)**

(ii)     The temperature used in the Haber process for the production of ammonia is 450 °C.

Why is a temperature much lower than 450 °C **not** used for the Haber process?

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**(1)**

(iii)    Use the information in the figure to answer this question.

Draw a ring around the pressure that gives the highest yield of ammonia.

|  |  |  |  |
| --- | --- | --- | --- |
| **100** | **200** | **300** | **400** |

**(1)**

(iv)    The pressure used in the Haber process for the production of ammonia is 200 atmospheres. Why is a pressure lower than 200 atmospheres **not** used for the Haber process?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(c)     Explain how ammonia is separated from unreacted nitrogen and hydrogen in the Haber process.

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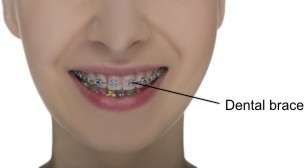
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**(2)**

**(Total 8 marks)**

**Q10.** Dental braces are made from nitinol wires. Nitinol is a mixture of metals.



(a)     Nitinol can return to its original shape after being deformed.

Draw a ring around the correct answer to complete the sentence.

|  |  |
| --- | --- |
| Nitinol is a shape memory | alloy.  catalyst.  polymer. |

**(1)**

(b)     **Figure 1** shows the arrangement of atoms in a pure metal and in a mixture of metals.

**Figure 1**

|  |  |
| --- | --- |
| **Pure metal** | **Mixture of metals** |
|  |  |

The mixture of metals is harder than the pure metal. Use **Figure 1** to explain why.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(c)     Gold and stainless steel are also used for dental braces.

Suggest **two** factors to consider when choosing which metal to use for dental braces.

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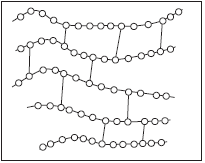
**(2)**

(d)     A thermosetting polymer is used to hold dental braces on the teeth.

**Figure 2** shows the structure of a thermosetting polymer.

**Figure 2**

**Thermosetting polymer**

****

How can you tell from **Figure 2** that the polymer is thermosetting?

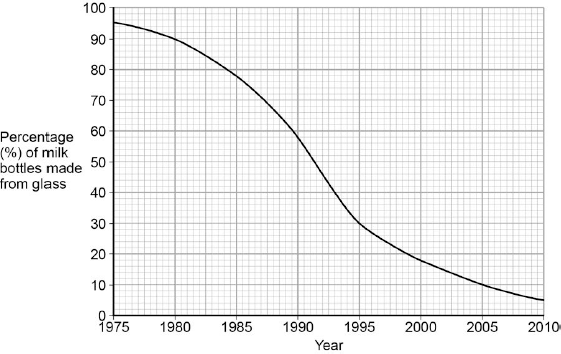
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**(1)**

**(Total 6 marks)**

**Q11.** Plastic and glass can be used to make milk bottles.The figure below shows the percentage of milk bottles made from glass between 1975 and 2010.



(a)     Plot the points and draw a line on the figure above to show the percentage of milk bottles made from materials **other** than glass between 1975 and 2010.

**(3)**

(b)     The table below gives information about milk bottles.

|  |  |  |
| --- | --- | --- |
|  | **Glass milk bottle** | **Plastic milk bottle** |
| Raw materials | Sand, limestone, salt | Crude oil |
| Bottle material | Soda-lime glass | HD poly(ethene) |
| Initial stage in production of bottle material | Limestone and salt used to produce sodium carbonate. | Production of naphtha fraction. |
| Maximum temperature in production process | 1600 °C | 850 °C |
| Number of times bottle can be used for milk | 25 | 1 |
| Size(s) of bottle | 0.5 dm3 | 0.5 dm3, 1 dm3, 2 dm3, 3 dm3 |
| Percentage (%) of recycled material used in new bottles | 50 % | 10 % |

Evaluate the production and use of bottles made from soda-lime glass and those made from HD poly(ethene).

Use the information given and your knowledge and understanding to justify your choice of material for milk bottles.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(6)**

**(Total 9 marks)**

**Q12.** This question is about ammonia and fertilisers.

(a)     Ammonia is produced by a reversible reaction.

The equation for the reaction is:

N2   +   3H2   ⇌   2NH3

Complete the sentence.

The forward reaction is exothermic, so the reverse reaction

is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(b)     Calculate the percentage by mass of nitrogen in ammonia (NH3).

Relative atomic masses (Ar): H = 1; N = 14

You **must** show how you work out your answer.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Percentage by mass of nitrogen = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ %

**(3)**

(c)     A neutral solution can be produced when ammonia reacts with an acid.

(i)      Give the pH of a neutral solution.

pH \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(ii)     Which of these ionic equations shows a neutralisation reaction?

|  |  |
| --- | --- |
| Tick (✔) **one** box. |  |
| H+ + OH⁻  →  H2O |  |
| NH4+ + OH⁻  →  NH4OH |  |
| H+ + Cl⁻  →  HCI |  |
| H+ + H2O  →  H3O+ |  |

**(1)**

(iii)     Name the salt produced when ammonia reacts with hydrochloric acid.

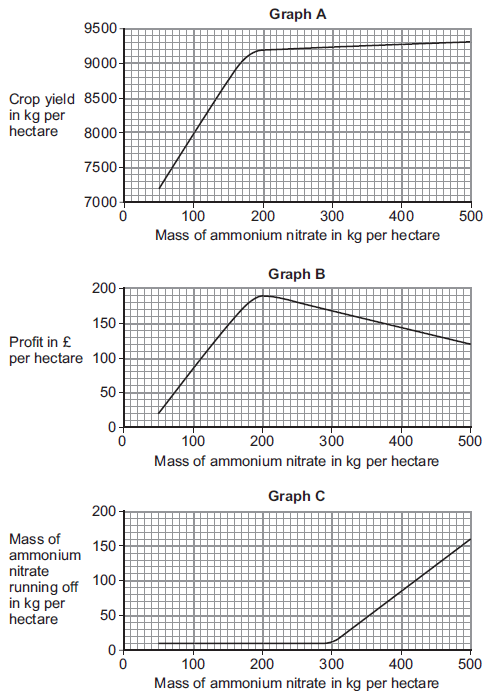
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**(1)**

(d)     **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Farmers use ammonium nitrate as a fertiliser for crops. Rainwater dissolves ammonium nitrate in the soil. Some of the dissolved ammonium nitrate runs off into rivers and lakes.

The graphs **A**, **B** and **C** below show information about the use of ammonium nitrate as a fertiliser. A hectare is a measurement of an area of land.



Suggest how much ammonium nitrate farmers should use per hectare. Give reasons for your answer.

Use information from graphs **A**, **B** and **C**.

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**(6)**

**(Total 13 marks)**

**Q13.**This question is about metals and alloys.

(a)     Explain how electricity is conducted in a metal.

To gain full marks you must include a description of the structure and bonding of a metal.

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**(4)**

(b)     Describe how the structure of an alloy is different from the structure of a pure metal.

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**(2)**

(c)     Alloys are used to make dental braces and coins.

(i)      Nitinol is an alloy used in dental braces. Why is Nitinol used in dental braces?

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**(1)**

(ii)     Suggest **one** reason why coins are not made of pure copper. Do **not** give cost as a reason.

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**(1)**

(iii)    Some coins are made from an alloy of aluminium. Complete the sentence.

Aluminium is manufactured by the electrolysis of a molten mixture of cryolite

and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ .

**(1)**

(iv)    Banks keep coins in poly(ethene) bags. These bags are made from low density poly(ethene). High density poly(ethene) can also be made from the same monomer.

How can the same reaction produce two different products?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(d)     Give **two** reasons why instrumental methods of analysis are used to detect impurities in metals.

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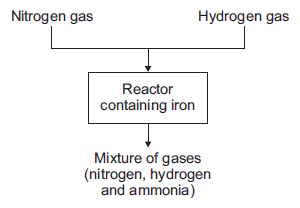
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**(1)**

**(Total 11 marks)**

**Q14.** The graph in **Figure 1** shows a flow diagram for the Haber process.

**Figure 1**

****

(a)     (i)      Hydrogen gas is obtained from methane. Name **one** source of methane.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(ii)     Air is the source used to produce nitrogen for the Haber process.

Suggest why air must **not** get into the reactor.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(iii)     Describe what happens to the mixture of gases from the reactor.

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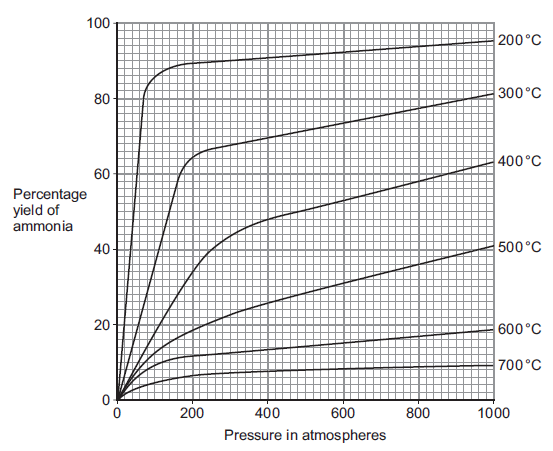
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**(3)**

(b)     The graph in **Figure 2** shows the percentage yield of ammonia using different conditions.

**Figure 2**

****

(i)      Use **Figure 2** to suggest the conditions that produce the greatest yield of ammonia.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(ii)      Use **Figure 2** to suggest and explain why the conditions used to produce ammonia in the Haber process are a temperature of 450 °C and a pressure of 200 atmospheres.

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**(5)**

**(Total 12 marks)**

Mark schemes

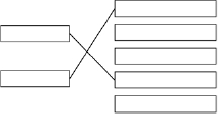
**Q1.**

(a)     S(s)

**1**

(b)     measuring cylinder

**1**

(c)     

**1**

*allow for* ***1*** *mark an answer of dependent variable --- concentration of sodium thiosulfate solution and independent variable --- time for cross to become no longer visible*

**1**

(d)     cross might be darker or paler

*allow cross may not be the same size / shape*

**1**

(e)     

*an answer of 42 (s) scores* ***2*** *marks*

**1**

= 42 (s)

*an answer of 54 (s) scores* ***1*** *mark*

**1**

(f)      smooth curve through all points

*must touch all crosses do* ***not*** *allow straight lines between points*

*ignore attempt to plot* ***X***

**1**

(g)     reproducible

**1**

(h)     particles collide more frequently

**1**

there are more particles in a fixed volume

**1**

**[11]**

**Q2.** (a)     (i)      oxygen, sulfur trioxide*both needed for mark*

**1**

(ii)     compound

**1**

(b)     increases

*accept (goes) higher / (goes) up / (is) faster) / (are) more frequent*

**1**

(c)     activation

**1**

(d)     catalyst **or** increase temperature

**1**

**[5]**

**Q3.**

(a)     sulfur

**1**

precipitate

*allow solid*

**1**

(b)     any **one** from:

•   (volumetric) pipette

•   burette

**1**

(c)     any **one** from:

•   concentration of hydrochloric acid

•   volume of hydrochloric acid

•   volume of sodium thiosulfate solution

•   temperature (of solution)

•   darkness of cross

*allow same cross*

•   same stirring / swirling

**1**

(d)     7 points plotted correctly

*allow tolerance of ± half a small square*

*allow 5 or 6 points plotted correctly for* ***1*** *mark*

**2**

line of best fit

*must avoid anomalous point*

**1**

(e)     repeatable

*do* ***not*** *accept reproducible*

**1**

(f)      discard any anomalous results

**1**

calculate a mean

**1**

(g)     **conclusion:**

the higher the concentration, the higher the rate of reaction

**1**

**explanation:**

(at higher concentrations) there are more particles in a fixed volume

**1**

(therefore the) collisions are more frequent

**1**

*allow converse*

(h)     120 (s)

**1**

0.18 / 120

*allow 0.0015*

**1**

= 1.5 × 10−3 (g / s)

*an answer of 9 × 10−2 scores* ***2*** *marks*

*allow an answer of 0.09 for* ***1*** *mark*

**1**

*an answer of 1.5 × 10−3 (g / s) scores* ***3*** *marks*

**[16]**

**Q4.**

(a)     in a closed system

**1**

the rate of the forward and backward reactions are equal

**1**

(b)     concentration increases

**1**

(because) reaction / equilibrium moves to the left / reactant side

**1**

(since the) reverse reaction is exothermic

*allow (so that) temperature increases*

**1**

(c)     becomes blue

**1**

(because) reaction / equilibrium moves to the right / product side

**1**

(so) concentration of blue cobalt compound increases

*allow (so that) concentration of hydrochloric acid decreases*

**1**

(d)     (cobalt has) ions with different charges

*allow (cobalt is a) transition metal*

**1**

(e)     Co3+

**1**

(f)      they allow reactions to reach equilibrium more quickly

**1**

they provide a different reaction pathway

**1**

(g)     **13**H2 + **6**CO → C6H14 + **6**H2O

*allow multiples*

**1**

(h)     C8H18

**1**

(i)      curve below printed curve

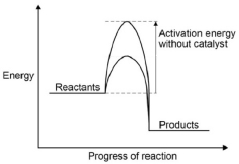
*do* ***not*** *accept different reactant or product levels*

**1**

vertical arrow from reactant level to peak of **printed** curve

**1**

an answer of:



scores **2** marks

**[16]**

**Q5.**

(a)     cotton wool

**1**

(b)     all points correct *± ½ small square*

**2**

*allow* ***1*** *mark if 5 or 6 of the points are correct*

best fit line *must not deviate towards anomalous point*

**1**

(c)     (mass)

2.1 (g) *allow ecf from drawn best fit line*

**1**

(time)

100 (s)

**1**

(d)     a gas is produced

**1**

which escapes from the flask

**1**

(e)    

**1**

0.07 (g / s)

*allow ecf answer correctly calculated to 2 decimal places*

**1**

(f)     collect the gas in a gas syringe

**1**

measured the volume of gas

*allow carbon dioxide for gas*

**1**

*allow for* ***1*** *mark*

*collected gas*

***or***

*counted bubbles*

(g)     The particles have more energy

**1**

The particles move faster

**1**

**[14]**

**Q6.**

(a)     any **two** from:

•        temperature (of the HCl)

•        mass or length of the magnesium

•        surface area of the magnesium

•        volume of HCl

**2**

(b)     (i)      (a greater concentration has) more particles per unit volume

*allow particles are closer together*

**1**

therefore more collisions per unit time **or** more frequent collisions.

**1**

(ii)     particles move faster

*allow particles have more (kinetic) energy*

**1**

therefore more collisions per unit time **or** more frequent collisions

**1**

collisions more energetic (therefore more collisions have energy greater than the activation energy) **or** more productive collisions

**1**

(c)     (i)       add (a few drops) of indicator to the acid in the conical flask

*allow any named indicator*

**1**

add NaOH (from the burette) until the indicator changes colour **or** add the NaOH dropwise

*candidate does not have to state a colour change but penalise an incorrect colour change.*

**1**

repeat the titration

**1**

calculate the **average** volume of NaOH **or** repeat until concordant results are obtained

**1**

(ii)     **moles of NaOH**

0.10 × 0.0272 = 0.00272 moles

*correct answer with or without working gains* ***3*** *marks*

**1**

**Concentration of HCl**

0.00272 / 0.005 = 0.544

*allow ecf from mp1 to mp2*

**1**

correct number of significant figures

**1**

**[14]**

**Q7.**

(a)     because sulfur / S (forms)

**1**

(which) is solid / insoluble / a precipitate / a suspension

**1**

(b)     any **two** from:

•        volume of sodium thiosulfate

*ignore amount of sodium thiosulfate*

•        volume of (hydrochloric) acid

*ignore amount of (hydrochloric) acid*

•        concentration of sodium thiosulfate

•        concentration of (hydrochloric) acid

*if no other mark, allow* ***1*** *mark for same cross* ***or*** *same flask* ***or*** *unspecified volume* ***or*** *unspecified concentration*

*ignore same person*

*do* ***not*** *accept references to temperature*

**2**

(c)     rate increases

**1**

because particles move faster

*accept particles have more energy*

**1**

so frequency of collisions increases

*accept particles are more likely to collide* ***or*** *more chance of collisions*

*ignore more collisions*

**1**

more particles / collisions have energy greater than (or equal to) the activation energy

**1**

(d)     cool

*accept refrigerate* ***or*** *method to decrease temperature*

**or**

decrease the temperature (of the solutions)

**1**

**[9]**

**Q8.**

(a)     (i)      nothing can enter **and** nothing can leave the reaction

*allow sealed reaction vessel*

**1**

(ii)     forward and backward reactions have same rate

**1**

so there is no (overall) change in quantities of reactants and products

*allow concentrations of reactants and products*

**1**

(b)     (i)      natural gas

*allow methane / CH4*

*allow fossil fuels / hydrocarbons*

*allow water*

**1**

(ii)     provides an alternative reaction pathway

**1**

which has a lower activation energy *ignore references to collisions*

**1**

(iii)    the amount (of ammonia) increases *allow yield increases*

**1**

the equilibrium moves to the side (of the equation) with fewer (gaseous) molecules / moles *allow it favours the forward reaction*

**1**

(c)     (i)      vertical arrow from reactants to maximum

**1**

(ii)     (energy of) products higher than (energy of) reactants

*allow converse*

**1**

(iii)    amount of hydrogen iodide decreases

**1**

equilibrium moves in the direction of the endothermic reaction

*allow it favours the forward reaction*

**1**

**[12]**

Mark schemes

**Q1.**

(a)     C5H12

**1**

(b)     2:5

**1**

(c)     **A**

**1**

(d)     **A**

**1**

(e)     carbon dioxide

**1**

water

**1**

(f)      propane

**1**

(g)     (8 × 1) + (3 × 12)

**1**

= 44

**1**

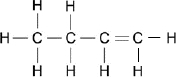
*an answer of 44 scores* ***2*** *marks*

**[9]**

**Q2.**

(a)     C5H10

**1**

(b)     

**1**

(c)     bar labelled petrol to 28.6 (%)

*allow a tolerance of ±  a square*

**1**

(d)     100 tonnes

**1**

(e)     7.1 + 11.1 + 17.2 = 35.4

**1**

****  *allow ecf from step 1*

**1**

= 708 (kg) *an answer of 1276 (kg) gains* ***2*** *marks*

**1**

(f)      higher percentage (by mass) of heavier fractions

**or**

higher percentage of larger molecules

**1**

(g)     **Level 3 (5-6 marks):**

Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.

**Level 2 (3-4 marks):**

Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.

**Level 1 (1-2 marks):**

Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

**Level 0**

No relevant content.

**Indicative content**

**fractional distillation**

•   oil heated / boiled / vaporised

•   fractionating column used

•   fractions have different boiling ranges / temperatures

•   column hotter at bottom

**or**

column cooler at top

•   fractions condense at different levels

•   heavy fractions collect at bottom

or

light fractions collect at top

**cracking**

•   high temperature

•   catalyst or steam

•   large molecules split into small molecules

•   mixture of alkanes and alkenes produced

**6**

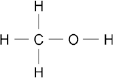
**[14]**

**Q3.** (a)     Propanol

**1**

(b)     Butanol has the highest boiling point

**1**

(c)    

**1**

(d)     ethene  +  water   (→   ethanol)

*allow answers in either order allow steam for water*

**1**

(e)     goes back to reactor *allow is recycled*

**1**

(f)     air contains oxygen

**1**

which oxidises ethanol *allow ethanol reacted with oxygen*

**1**

to produce ethanoic acid

**1**

**[8]**

**Q4.** (a)    C6H14

**1**

(b)     **A**

**1**

(c)     **B**

**1**

(d)     **C**

**1**

(e)     Propanol

**1**

**[5]**

**Q5.** (a)     (i)      ethanol

**1**

(ii)     oxidised

**1**

(iii)    **Test**

add any named carbonate or hydrogen carbonate *the first mark is for the test; the second is for the result if the test is incorrect award 0 marks.*

**1**

**Result**

**A** will effervesce (carbon dioxide) **or** **B** will not effervesce. *if the result is incorrect, award the first mark only*

**1**

**or**

*candidates do not have to name a gas but penalise an incorrect gas.*

**Test**

add a named (magnesium, aluminium, zinc, iron or tin) metal

*give credit to any test that will work.*

**Result**

**A** will effervesce (hydrogen), **B** will not *allow a test that would identify* ***B****.*

**or**

**Test**

add an acid-base indicator

**Result**

credit any acid colour for that indicator eg for universal indicator allow red, yellow or orange give credit for the neutral colour for **B**

**or**

**Test**

add an alcohol (+ acid catalyst)

**Result**

sweet or fruity smell of esters.

(b)     (i)      H2O

**1**

(ii)     ethyl ethanoate

**1**

(iii)    any **one** from:

•        flavourings

•        perfumes

•        solvents

•        plasticisers

*allow any correct use of esters*

**1**

**[7]**

**Q6.** (a)     any **two** from:

•        fuel

*allow source of energy*

•        solvent

*allow perfume / aftershave*

•        antiseptic

*allow antibacterial*

**2**

(b)     Hydrogen

**1**

(c)     (i)      oxidation

*do* ***not*** *allow redox*

**1**

(ii)     correct structure

**1**

(iii)    ethanoic acid is a weak / weaker acid

*it = ethanoic acid*

**1**

because it does not completely ionise.

*allow because it does not completely dissociate*

*allow it has a lower concentration of hydrogen ions*

*allow converse for hydrochloric acid*

*do* ***not*** *allow ionising*

**1**

(d)     (i)      ethyl ethanoate

**1**

(ii)     acid

*allow any strong acid*

*allow correct formulae*

**1**

(iii)    evaporates easily / quickly

*allow low boiling point*

*do* ***not*** *allow flammable*

**1**

**[10]**

**Q7.**

(a)     oxygen

*allow correct answer shown in box if answer line blank*

**1**

(b)     vinegar

*allow correct answer shown in box if answer line blank*

**1**

(c)     C

**1**

(d)     Ester

**1**

(e)     pleasant smell

**1**

volatile

*allow low boiling point / evaporates*

**1**

**[6]**

**Q8.**

(a)     *(ethene)*

**

**1**

*(polyethene)*

**

**1**

(b)     any **four** from:

•        poly(ethene) produced by addition polymerisation whereas polyester by condensation polymerisation

•        poly(ethene) produced from one monomer wheareas polyester produced  
from two different monomers

•        poly(ethene) produced from ethene / alkene whereas polyester from a (di)carboxylic acid and a diol / alcohol

•        poly(ethene) is the only product formed whereas polyester water also  
produced

•        poly(ethene) repeating unit is a hydrocarbon whereas polyester has an ester linkage

**4**

**[6]**

**Q9.**

(a)     (i)      25 °C

**1**

(ii)     (fractional) distillation

**1**

(b)     (i)      (fertile) land is used to grow fuel crops **or** crops are grown for fuel **or** farmers get a better price for crops for fuel **or** crops for biofuels take up space

*ignore biofuels are made from food or plants*

**1**

less food grown **or** food prices rise **or** less (fertile) land to grow food

**1**

(ii)     (crops / plants) take in carbon dioxide (while growing / during photosynthesis)

**1**

so the CO2 given out was previously taken in

*do* ***not*** *accept burning biofuels does not release CO2 or releases less CO2 unqualified*

*if no other mark awarded, a statement of “carbon neutral” scores* ***1*** *mark*

**1**

(c)     Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking Guidance and apply a ‘best–fit’ approach to the marking.

**0 marks**No relevant content

**Level 1 (1−2 marks)**At least one statement about the effect of a condition on either rate **or** yield.

**Level 2 (3−4 marks)**Correct statements about the effect of at least one condition on rate **and** yield.

**Level 3 (5−6 marks)**Correct statements about the effect of at least one condition on rate and yield **and** at least one correct statement about compromise conditions.

**Examples of the points made in the response**

**Temperature**

•        a higher temperature gives a lower yield

•        a higher temperature gives a faster rate

**Pressure**

•        a higher pressure gives a higher yield

•        increase in yield gets less as pressure increases

•        a higher pressure gives a faster rate

•        increase in rate increases as pressure increases

**Catalyst**

•        using a catalyst speeds up reaction

•        catalysts allow a lower temperature to be used and so save energy / reduce energy costs

**Compromise**

•        a higher pressure gives a greater yield but increases costs / (safety) risks

•        a high pressure gives a faster rate but increases costs / risks

•        a high temperature makes reaction faster but reduces yield

•        a catalyst makes reaction faster so a lower temperature can be used which will increase the yield

**6**

**[12]**

**Q10.** (a)     any **one** from:

•        disposal or does not decompose (in landfill sites) or collection or sorting for recycling

*ignore non-biodegradable alone*

•        lack of space or more landfill sites

•        other specified problems with waste (eg. litter **or** eyesore **or** harm to animals **or** destroys habitats)

*ignore pollution unqualified.*

**1**

(b)



*if 2 marks not awarded, award* ***1*** *mark for* ***one*** *of the following:*

*•        a double bond between the two carbons and no  
         additional trailing bonds*

*•        two C atoms bonded together with three single  
         bonds to hydrogen atoms and one single bond to  
         a chlorine atom. no additional Cl or H.*

**2**

(c)     intermolecular forces **or** forces between the chains

*allow intermolecular bonds*

**1**

(intermolecular forces are) weak

*ignore references to no cross links between chains.*

*allow 1 mark for weak forces between layers.*

**1**

which are easily overcome (by heat) **or** need little energy to overcome **or** chains / molecules can slide over one another (when heated)

*if weak bonds* ***or*** *breaking covalent bonds mentioned only the third marking point is available.*

**1**

(d)     Monomer **A** − carboxylic acid

*do not allow carbolic*

**1**

Polymer **C** - ester (linkage)

**1**

**[8]**

**Q11.**

(a)     water / H2O

*allow steam or hydrogen oxide*

**1**

(b)     (i)      A

**1**

(ii)     exothermic

**1**

products (energy) lower than reactants (energy)

**1**

(iii)     1860 (kJ)

**1**

(c)     (i)      22.5

**1**

38.7

**1**

16.2

*allow ecf for correct subtraction*

**1**

(ii)     50 (g)

**1**

(iii)    20.1 (kJ)

*allow propanol*

*ignore 3*

**1**

(iv)    as the number of carbon atoms (in one molecule of alcohol) increases the heat energy given out increases (when the alcohol is burned)

**1**

(v)     any **two** from:

•        no lid

•        no insulation

•        no draught shield

*Allow heat / energy loss to surroundings for any one of these marks*

•        incomplete combustion

•        inaccurate measurement

•        no repeats (to calculate a mean)

**2**

(iv)    -O-H

**1**

**[14]**

**Q12.**

(a)     both water vapour and ethanol will condense

*allow steam for water vapour*

*allow they both become liquids*

*allow ethane condenses at a lower temperature*

*allow some of the steam hasn’t reacted*

*allow it is a reversible reaction / equilibrium*

**1**

(b)     amount will decrease

**1**

because the equilibrium will move to the left

**1**

(c)     more ethanol will be produced

**1**

because system moves to least / fewer molecules

**1**

**[5]**

Mark schemes

**Q1.**

(a)     

**1**

= 15.6(25) (g)

**1**

*an answer of 15.6(25) (g) scores* ***2*** *marks*

(b)     copper (ions)

*allow in either order*

**1**

sulfate (ions)

**1**

(c)     flame test

**1**

yellow (flame)

**1**

(d)     add dilute acid

*allow named acid*

**1**

(bubble gas produced through) limewater

**1**

(turns) cloudy / milky

*allow forms white precipitate*

**1**

**[9]**

**Q2.**

(a)     The start line was drawn in ink

**1**

The water level was above the spots

**1**

(b)     3

**1**

(c)     **A**

**1**

(d)     *(distance moved by dye A)* 38 (mm)

*allow values in range 36-40*

**1**

*(distance from start line to solvent front)*

102 (mm)

*allow values in range 101-103*

**1**

****

*allow ecf from Table 1*

**1**

0.37254 …

*allow values in range 0.35 − 0.39*

**1**

0.37

**1**

*accept 0.37 with no working shown for* ***5*** *marks*

**[9]**

**Q3.**

(a)     copper (II) → blue

iron (III) → brown

*more than one line from any box negates the mark*

**1**

**1**

(b)     aluminium

*allow correct answer shown in box if answer line blank*

**1**

(c)     (i)      yellow

*allow orange*

**1**

(ii)     lilac

*allow purple*

**1**

(iii)    one colour masks the other

*allow colours mixed*

**1**

**[6]**

**Q4.**

(a)    additive

**1**

(b)     colour 3 is a mixture of colours 1 and 2

any **two** from:

*accept E-number or additive instead of colour*

*ignore comments about height / level*

**1**

•        colour 1 is made up of only one colour / dye

•        colour 2 is made up of only one colour / dye

•        colour 3 is made up of two colours / dyes   
**or**   
more colours (than colours 1 and 2)

**2**

**[4]**

**Q5.**

(a)     water level above the start line

**and**

start line drawn in ink

*allow water level too high*

**1**

*water level*

food colours would dissolve into water

**or**

*start line*

the ink would ‘run’ on the paper

**1**

(b)     (distance moved by **A**) 2.8cm **and** 8.2 cm (distance moved by solvent)

*allow values in range 2.7 − 2.9 cm and 8.1 − 8.3 cm*

**1**

****

**1**

0.34

*allow 0.33 or 0.35*

*allow ecf from incorrect measurement to final answer for* ***2*** *marks if given to 2 significant figures*

*accept 0.34 without working shown for* ***3*** *marks*

**1**

(c)     6.6 cm

*allow values between 6.48 and 6.64 cm*

**1**

(d)     solvent moves through paper

**1**

different dyes have different solubilities in solvent

**1**

and different attractions for the paper

**1**

and so are carried different distances

**1**

(e)     calcium ions

*allow Ca2+*

**1**

sodium ions

*allow Na+*

**1**

(f)     two different colours

**or**

Ca2+ / one is orange-red and Na+ / the other is yellow

*allow brick red for Ca2+ and / or orange for Na+*

*allow incorrect colours if consistent with answer to* ***7.5***

**1**

(so) colours mix

**or**

(so) one colour masks the other

**1**

(g)     (Student **A** was incorrect)  
because sodium compounds are white not green

**or**

because sodium carbonate is soluble

**1**

so can’t contain sodium ions

**1**

(Student **B** was incorrect)  
because adding acid to carbonate produces carbon dioxide

**1**

so must contain carbonate not chloride ions

**1**

**[18]**

**Q6.**

(i)      correct named instrumental method

eg

atomic absorption spectroscopy / spectrometry

*accept atomic / absorption spectroscopy*

*accept aas*

**or**

mass spectrometry / spectroscopy

*accept mass spec*

**or**

infrared (spectrometry) / IR

**or**

ultraviolet / spectroscopy / UV

**or**

nuclear magnetic spectroscopy / nmr

**or**

gas-liquid chromatography / GLC

**1**

(ii)      any **one** from:

•        fast / quick **or** comment about speed

*ignore lost*

*ignore human error*

•        small amount

*accept operators do not need chemical skills*

•        sensitive / accurate / precise

*ignore safe / easier to use*

•        ease of automation

•        reliable / efficient

•        can be left to run / continuous analysis

**1**

**[2]**

**Q7.**

(a)      (i)     yellow

**1**

(ii)     lilac

**1**

(iii)    melting point

**1**

(b)     (i)      barium chloride

**1**

solid

**1**

(ii)     white

**1**

dissolved

**1**

**[7]**

**Q8.**

(a)      limewater **or** calcium hydroxide solution

**1**

(reacts with carbon dioxide and) turns cloudy / milky

*linked to first point*

*if no other mark awarded ‘puts out lighted splint’ gains* ***1*** *mark*

**1**

(b)     (i)      any **two** from:

•        same volume / amount of the acids

•        concentration of the acids

•        temperature

•        same surface area / size / mass / amount of calcium carbonate

•        same measuring equipment

**2**

(ii)     any **three** from:

•        (after about 4 minutes) the sulfuric acid stops reacting **or** nitric acid continues to react

*accept more CO2 with nitric acid at any time after 4 minutes*

•        (initially) the reaction with sulfuric acid is faster

•        (the reaction stops) because calcium sulfate is a solid

*allow sulfuric acid produces a solid*

•        (the reaction continues) because calcium nitrate is soluble / in solution / aqueous

*allow nitric acid produces an (aqueous) solution*

•        because the calcium sulfate prevents the sulfuric acid reacting with the calcium carbonate

•        (the rate is faster) because sulfuric acid contains two hydrogens

**3**

**[7]**

**Q9.**

(a)     (i)      Na2CO3: HCl → gas / effervescence / bubbles (1)  
               CO2  / carbon dioxide / turns lime water milky (1)

**1**

NaCl: AgNO3  → white ppt (1)  
                           silver chloride (1)

**1**

NaNO3: Al + NaOH → pungent / sharp smell / choking gas (1)  
                                    NH3  / ammonia / turns (red) litmus blue(1)

**1**

Na2SO4: BaCl2  → white ppt (1)  
                              barium sulfate (1)

**1**

*each correct test and one result =* ***1*** *mark*

***one*** *other result for any test =* ***1*** *mark this mark can only be awarded once*

(ii)     all would give a yellow / yellow-orange (flame) / same coloured (flame) / same results

*allow orange (flame) 1*

**or**

they all contain sodium

**1**

(b)     any **two** from:

*ignore cost/errors*

•        fast / quick or comment about speed

*allow precise*

•        small amounts/sensitive

*allow can be left to run/continuous analysis*

•        accurate

•        ease of automation

*accept operators do not need chemical skills*

•        sample not used up

•        reliable / efficient

**2**

**[7]**

**Q10.**

(a)     **X:**

Fe2+ / iron(II), SO42- / sulfate

*allow iron(II) sulfate****or*** *FeSO4*

**1**

**Y:**

Na+ / sodium, I- / iodide

*allow sodium iodide****or*** *NaI*

**1**

**Z:**

Fe3+ / iron(III), Br- / bromide

*allow iron(III) bromide****or*** *FeBr3*

*correct identification of any two ions = one mark*

*correct identification of any four ions = two marks*

**1**

(b)     any **five** from:

*allow converse arguments*

method 1

•        weighing is accurate

•        not all barium sulfate may be precipitated

•        precipitate may be lost

•        precipitate may not be dry

•        takes longer

•        requires energy

*allow not all the barium hydroxide has reacted*

method 2

•        accurate

•        works for low concentrations

*allow reliable / precise*

**5**

**[8]**

**Q11.**

(a)     lithium

*allow Li+ / Li*

**1**

yellow

*allow orange*

**1**

(b)     silver nitrate (solution)

*incorrect test =* ***0*** *marks*

*ignore (nitric) acid*

*do* ***not*** *allow other named acids*

**1**

white precipitate

**1**

(c)     blue precipitate (with sodium hydroxide) indicates copper ions

*allow Cu2+*

**1**

and white precipitate (with barium chloride) indicates sulfate ions

*allow SO42-*

*accept compound X is copper sulfate / CuSO4 for* ***1*** *mark*

**1**

but iron(II) ions produce a green precipitate (with sodium hydroxide)

**1**

**[7]**

Mark schemes

**Q1.**

(a)     crust

*ignore Earth’s*

**1**

core

*ignore inner and/or outer*

**1**

(b)     bar chart

**1**

all heights are correct

*accept correctly plotted points*

**1**

all labels are correct for nitrogen, oxygen and other / argon

**1**

(c)     (i)      decomposed

**1**

(ii)     global warming

**1**

**[7]**

**Q2.**

(a)     sulfur dioxide

**1**

(b)     any **one** from:

•   kills aquatic animals / plants

•   damages limestone buildings / statues

•   damage to forests

**1**

(c)     (sample) **C**

**1**

contains most sulfur

**or**

produces most sulfur dioxide

**1**

(d)     

**1**

= 3 (kg)

**1**

*an answer of 3 (kg) scores* ***2*** *marks*

(e)     any **two** from:

•   not easily detected

•   colourless

*allow cannot see it*

•   odourless

*allow cannot smell it*

**2**

**[8]**

**Q3.**

(a)     any **one** from:

•        not enough evidence or proof

*allow no evidence or no proof*

•        (life and the Earth were created) billions of years ago

*allow a long time ago*

*ignore different beliefs or no one was there.*

**1**

(b)     Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking Guidance and apply a ‘best–fit’ approach to the marking.

**0 marks**No relevant content

**Level 1 (1−2 marks)**Statements based on diagrams

**Level 2 (3−4 marks)**Description of how one change occurred

**Level 3 (5−6 marks)**Descriptions of how at least two changes occurred

**Examples of chemistry points made in the response could include:**

**Main changes**

•        oxygen increased because plants / algae developed and used carbon dioxide for photosynthesis / growth producing oxygen; carbon dioxide decreased because of this

•        carbon dioxide decreased because oceans formed and dissolved / absorbed carbon dioxide; carbon dioxide became locked up in sedimentary / carbonate rocks and / or fossil fuels

•        oceans formed because the Earth / water vapour cooled and water vapour in the atmosphere condensed

•        continents formed because the Earth cooled forming a supercontinent / Pangaea which formed the separate continents

•        volcanoes reduced because the Earth cooled forming a crust.

**Other changes**

•        nitrogen has formed because ammonia in the Earth’s early atmosphere reacted with oxygen / denitrifying bacteria.

**6**

**[7]**

**Q4.**

(a)    any **two** from:

*asks for cause therefore no marks for just describing the change*

*must link reason to a correct change in a gas*

**carbon dioxide has decreased due to:**

*accept idea of ‘used’ to indicate a decrease*

•        plants / microorganisms / bacteria / vegetation / trees

•        photosynthesis

*ignore respiration*

•        ‘locked up’ in (sedimentary) rocks / carbonates / fossil fuels

•        dissolved in oceans

*ignore volcanoes*

**oxygen has increased due to:**

*accept idea of ‘given out / produced’*

•        plants / bacteria / microorganisms / vegetation / trees

•        photosynthesis

*ignore respiration*

**nitrogen increased due to:**

*accept idea of ‘given out / produced’*

•        ammonia reacted with oxygen

•        bacteria / micro organisms

*ignore (increase in) use of fossil fuels / deforestation*

**2**

(b)     (because methane’s) boiling point is greater than the average / surface temperature **or** Titan’s (average / surface) temperature is below methane’s boiling point

*ignore references to nitrogen* ***or*** *water*

**1**

any methane that evaporates will condense

*accept boils for evaporates*

*accept cooling and produce rain for condensing*

**1**

(c)     CnH2n

**1**

**[5]**

**Q5.**

(a)     oxygen **and** nitrogen

**1**

20 – 21 % and 78 – 80 %

*accept any two correct responses in the correct space for* ***one*** *mark*

**1**

(b)     (i)      acid rain

*accept toxic gas or consequence of acid rain*

**1**

(ii)     idea of the removal or use of sulfur  
dioxide gas (from the waste gases)

*do* ***not*** *accept remove sulfur from coal*

**1**

(iii)     oxygen

*accept O2*

**1**

water

*accept H2O  
accept hydrogen oxide / steam*

**1**

(c)     any **two** from:

•        it’s a ‘greenhouse gas’ or increase greenhouse effect

*accept action of a ‘greenhouse gas’*

•        causes global warming or increase in the Earth’s temperature

•        sea-levels rise or flooding

•        climate change

•        (polar) ice-caps melt

•        extension of deserts

*mention of ozone / acid rain / global dimming = max* ***1*** *mark*

**2**

(d)     idea trap / store / lock the carbon dioxide

**1**

in the oil reservoir or under the sea bed

*do* ***not*** *accept ‘into the oil’ / ‘under the sea’*

**1**

**[10]**

**Q6.**

(a)     core

*ignore outer or inner*

**1**

mantle

**1**

(b)     (i)      carbon dioxide

*accept formula CO2*

**1**

oxygen

*accept formulae O2 / O*

**1**

(ii)     4%

**1**

(iii)     carbon dioxide has decreased / from 95% to 0%

**1**

oxygen has increased / from 0% to 21%

**1**

any **one** from:

(carbon dioxide decrease)

•        carbon dioxide used during photosynthesis / by plants

•        carbon dioxide dissolves in oceans

•        carbon dioxide is locked up in rocks / carbonates / fossil fuels

          (oxygen increase)

•        oxygen released during photosynthesis / by plants

**1**

**Q7.**

(a)     Methane

**1**

(b)     Sea levels rising

**1**

(c)     Burning of fossil fuels

**1**

(d)     carbon dioxide concentration stayed constant from 1850 to 1900

**1**

carbon dioxide concentration slowly increased from 1900

**1**

carbon dioxide concentration increased more rapidly from 1965

*allow values from 1965 − 1975*

**1**

**[6]**

**Q8.**

(a)     72/24

*an answer of 3 (mm / year) scores* ***2*** *marks*

**1**

= 3 (mm / year)

*an answer of 3.125 (mm / year) scores* ***1*** *mark*

**1**

(b)     **Level 3 (5-6 marks):**

Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.

**Level 2 (3-4 marks):**

Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.

**Level 1 (1-2 marks):**

Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

**Level 0**

No relevant content

**Indicative content**

**description**

•   global air temperature has risen overall / erratically

•   mean sea level has risen (steadily)

•   carbon dioxide has risen steadily

•   methane has risen overall / erratically

**explanations**

•   (carbon dioxide increase because) increase in fossil fuel combustion

**or**

•   (carbon dioxide increase because) increase in deforestation

•   methane from cattle / landfill / rice plantations

•   carbon dioxide and / or methane trap heat

**or**

•   carbon dioxide and / or methane are greenhouse gases

•   polar ice caps melt

**or**

•   seawater expands

**linked explanation**

•   greenhouse gases linked to temperature rise

•   temperature rise linked to seawater level

**6**

(c)     any **two** from:

•   bias

•   simplified models

•   lack of peer review

*ignore reproducible*

**2**

**[10]**

**Q9.**

(a)     because sulfur dioxide causes acid rain

**1**

which kills fish / aquatic life **or** dissolves / damages statues / stonework **or** kills / stunts growth of trees

*if no other mark awarded then award 1 mark for sulfur dioxide is toxic or causes breathing difficulties.*

**1**

(b)     (i)      electrons are lost

**1**

(ii)     Cu2+ + 2e−→ Cu

*allow Cu2+→ Cu − 2e−*

*ignore state symbols*

**1**

(iii)    copper sulfate

*allow any ionic copper compound*

**1**

(c)     (lattice of) positive ions

**1**

delocalised electrons

*accept sea of electrons*

**1**

(electrostatic) attraction between the positive ions and the electrons

**1**

electrons can move through the metal / structure **or** can flow

*allow electrons can carry charge through the metal / structure*

*if wrong bonding named or described or attraction between oppositely charged ions then do not award M1 or M3 − MAX 2*

**1**

(d)     (copper compounds are absorbed / taken up by) plants

*allow crops*

**1**

which are burned

**1**

the ash contains the copper compounds

*do not award M3 if the ash contains copper (metal)*

**1**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| (e) | / Ar | 55.6 / 63.5 | 16.4 / 56 | 28.0 / 32 |
|  | moles | 0.876 | 0.293 | 0.875 |
|  | ratio | 3 | 1 | 3 |
|  | formula | Cu3FeS3 | | |

*award* ***4*** *marks for Cu3FeS3 with some correct working*

*award* ***3*** *marks for Cu3FeS3 with* ***no*** *working*

*if the answer is not Cu3FeS3 award up to* ***3*** *marks for correct steps from the table apply ecf*

*if the student has inverted the fractions award* ***3*** *marks for an answer of CuFe3S*

**4**

**[16]**

**Q10.**

(a)     Sulfur dioxide causes acid rain.

**1**

(b)     red / orange / yellow

*do* ***not*** *accept any other colours*

**1**

because sulfur dioxide (when in solution) is an acid

**1**

(c)     (there are) weak forces (of attraction)

*do* ***not*** *accept any reference to covalent bonds breaking*

**1**

between the molecules

*do* ***not*** *accept any other particles*

**1**

(these) take little energy to overcome

*award third mark only if first mark given*

**1**

(d)     Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5 and apply a ‘best-fit’ approach to the marking.

**0 marks**No relevant content

**Level 1 (1 – 2 marks)**A relevant comment is made about the data.

**Level 2 (3 – 4 marks)**Relevant comparisons have been made, and an attempt made at a conclusion.

**Level 3 (5 – 6 marks)**Relevant, detailed comparisons made and a justified conclusion given.

**examples of the points made in the response**

**effectiveness**

•        W removes the most sulfur dioxide

•        D removes the least sulfur dioxide

**material used**

•        Both W and D use calcium carbonate

•        Calcium carbonate is obtained by quarrying which will create scars on landscape / destroy habitats

•        D requires thermal decomposition, this requires energy

•        D produces carbon dioxide which may cause global warming / climate change

•        S uses sea water, this is readily available / cheap

**waste materials**

•        W product can be sold / is useful

•        W makes carbon dioxide which may cause global warming / climate change

•        D waste fill landfill sites

•        S returned to sea / may pollute sea / easy to dispose of

**6**

**[12]**

Mark schemes

**Q1.**

(a)     (i)      Filtration

**1**

(ii)     Chlorine

**1**

(b)     (i)      nanoparticles are small / smaller / much smaller / tiny

*allow any in range 1−100 nm or 1 × 10-9 m − 1 × 10-7 m* ***or*** *a few hundred atoms in size*

*ignore numbers if stated smaller*

**1**

(ii)     they have a high surface area to volume ratio

*reference to surface area without volume ratio is insufficient*

*allow nanoparticles are very reactive* ***or*** *nanoparticles are more reactive than normal particles.*

**1**

(c)     (sodium hydroxide) produces a white precipitate

*accept solid / suspension or ppt or ppte for precipitate.*

*ignore cloudy / milky*

**1**

which (then) dissolves / disappears (in excess sodium hydroxide)

*M2 cannot be awarded unless a solid of some sort has been made*

*ignore names or formulae of compounds*

**1**

**[6]**

**Q2.**

(a)     (i)      Solids

**1**

(ii)     Chlorine

**1**

(iii)    kill microbes / bacteria

*allow to make the water safe to drink*

*ignore disinfect*

*ignore remove / get rid of microbes*

**1**

(b)     energy

*allow heat*

**1**

(c)     improve dental health

*allow reduce tooth decay*

*allow (local) government requirement*

*allow help teeth*

**1**

**[5]**

**Q3.**

(a)     (i)      Solids

**1**

(ii)     Chlorine

**1**

(iii)     improves dental health **or** reduces tooth decay

**1**

(b)     put a sample of the filtered water in an evaporating basin **or** leave to evaporate

*accept any description of evaporation (using a Bunsen or leaving on the windowsill)*

**1**

there will be crystals of salt left

**1**

(c)     sodium and / or chloride ions are bigger than water (molecules) **or** ions are charged **or** molecules are not charged

*do* ***not*** *accept sodium chloride molecules as ions is given in the question*

**1**

**[6]**

**Q4.**

(a)     causes dust pollution

**1**

increases traffic

**1**

(b)     (i)      it is soft

*accept the layers of atoms can slide over each other*

*ignore other properties*

**1**

(ii)     contains chromium / nickel

*allow contains other metals*

**1**

(c)     (i)      an element

**1**

(ii)     hard

**1**

(iii)    is resistant to corrosion

**1**

**[7]**

**Q5.**

(a)     (i)      central block

**1**

(ii)     conducts electricity

**1**

(b)     any **two** from:

•        visual pollution

•        noise pollution

•        dust pollution

•        habitat destruction.

**2**

(c)     (i)      to concentrate the ore / copper carbonate

**or**

to remove / separate the rock

**1**

(ii)     12 (tonnes)

*If answer is incorrect allow one mark for (127 + 132) − 247 or*

*259 - 247*

**2**

(iii)    any **one** from:

•        so no reactant is wasted / left unreacted

•        so they know how much product they will make

•        need to record / compensate for the carbon dioxide produced

*allow so they can work out their carbon footprint.*

**1**

**[8]**

**Q6.**

(a)      (i)     reduction

*accept redox / smelting*

**1**

(ii)     3 4 3

**1**

(b)     (i)      55

*ignore other units*

(ii)     Water

*accept sodium hydroxide*

*accept correct formulae H2O or NaOH*

**1**

(iii)     any **one** from:

•   save energy / fuel for transporting the ore

*accept less (cost of) transport allow transported quickly*

•   (old) quarries nearby for waste/red mud

**1**

(c)     **Environmental**

any **one** from:

•   less mining / quarrying (of bauxite)

*allow loss of habitat / less qualified noise pollution*

•   less landfill space needed / used

*allow less red mud / waste*

•   less use of fossil fuels / energy

•   less carbon dioxide produced

**1**

**Ethical or social**

any **one** from:

•   saves resources

*allow using resources more than once*

•   creates (local) employment

*if answers reversed and both correct award* ***1*** *mark*

•   more people aware of the need for recycling

*allow less qualified noise pollution if not given in environmental*

**1**

**[7]**

**Q7.**

 (a)     (i)     cryolite

**1**

(ii)     lower the melting point of the aluminium oxide

**1**

(b)     (i)      opposite charges **or** oxide ions are negative

**1**

attract

**1**

(ii)     carbon

**1**

(iii)     reacts with oxygen **or** forms carbon dioxide

*accept burns*

**1**

(c)     **Structure mark:**

**either** Al (atoms) in layers / rows

*accept Al (atoms) all the same size  
allow Al (atoms) in lines*

**or** alloy (atoms) not in layers / rows

*accept different sizes of atoms in alloy  
allow alloy (atoms) not in lines*

**1**

**Sliding mark:**

**either** so (Al layers) can slide

**or** so (alloy) layers cannot slide

**1**

**[8]**

**Q8.**

(a)     (i)      economical

**1**

(ii)     phytomining

**1**

(iii)    carbon dioxide

**1**

(b)     (i)      copper / Cu

**1**

iron sulfate / FeSO4

**1**

(ii)     copper / ions have a positive charge

*it = copper ions*

*allow copper ions have a different charge*

*accept copper / ions are free to move*

*accept to gain electrons*

*accept copper / ions are attracted to the negative electrode* ***or*** *opposite charges attract*

**1**

(c)     any **two** from:

*ignore not biodegradable or does not decay*

•        copper ores are limited / running out

*allow copper is running out*

•        copper can be recycled

•        copper can be reused

•        copper is expensive

•        landfill sites are filling up

•        copper compounds are toxic

*allow copper is toxic*

**2**

**[8]**

**Q9.**

(a)     pure copper is twice as good a conductor as 99% pure copper

*accept reverse argument*

*accept answers quoting 2 correct values from the graph scores* ***2***

*qualitative answer (e.g. pure copper is a better conductor than impure copper) scores* ***1***

***or***

*answers quoting a conductivity value from the graph scores* ***1***

**2**

(b)     Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response.

**0 marks**

No relevant content

**Level 1 (1–2 marks)**

Simple list of a limited number of points given, with no linking between ideas

**Level 2 (3–4 marks)**

A broader set of points made. There will probably not be links between ideas

**Level 3 (5–6 marks)**

Answer includes linking between ideas, showing the consequence of either not recycling or the advantage of recycling. Answers such as less fossil fuel needed so less carbon dioxide produced **or** less carbon dioxide produced so less global warming

**examples of the points made in the response**

**resources**

**(recycling)** conserves supplies of ores

copper available for longer

as (at present rate of use) copper ores will run out in about 35 years

**(recycling)** conserves supplies of fossil fuels **or** energy

less fuel used at a lower cost

**land pollution**

mining scars landscape **or** produces noise pollution

mining destroys wildlife habitats

**(recycling)** less need to mine ores / fossil fuels

*so less habitat destroyed or less scarring of landscape*

**(recycling)** less need to use landfill for waste

**atmospheric pollution**

burning fossil fuels produces carbon dioxide / greenhouse gas

which (may) cause global warming **or** climate change

extraction produces sulfur dioxide

which causes acid rain

which can kill trees / fish

**6**

(c)     grow plants

*accept plants absorb copper (through roots)*

**1**

then plants are burned

**1**

ash (from burning) contains copper compounds

**1**

**[11]**

**Q10.**

(a)     The ore is not pure or contains impurities or the ore does not contain 100% of the metal compound

*allow to concentrate the metal or metal compound*

**1**

rock / other compounds need to be removed / separated

**1**

(b)     (i)      (cast iron is) brittle

*allow not strong*

*ignore weak*

**1**

(ii)     the oxygen reacts with carbon

*allow carbon burns in oxygen or is oxidised*

**1**

reducing the percentage of carbon in the mixture

**or** producing carbon dioxide

**1**

(c)     (i)      aluminium has a low density

**1**

(ii)     (because copper) is in the central / middle (block of the periodic table)

**1**

whereas aluminium is in Group 3 (of the periodic table)

**1**

(iii)    iron is more reactive (than copper)

*ignore cost*

**1**

so copper is displaced / reduced

**1**

**[10]**

Mark schemes

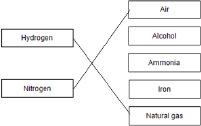
**Q1.**

(a)     4

**1**

(b)     reversible (reaction)

**1**

(c)     

**1**

**1**

(d)     −40 °C

**1**

(e)     recycled to the reactor

**1**

(f)      ionic

**1**

(g)     nitrogen

**1**

phosphorus

**1**

(h)     0.24 × 50 × 5

*allow £87.50*

**1**

= £60

**1**

*an answer of £60 scores* ***2*** *marks*

(i)      may need to use nitrogen, phosphorus and potassium

*allow neither fertiliser has all the elements / nutrients needed.*

**[12]**

**Q2.**

(a)     50

**1**

(b)     5%

**1**

(c)     any **two** from:

•        cost (9 carat is cheaper)

•        pure gold is soft

**or**

         24 carat gold is soft

**or**

         9 carat gold is harder

*allow 9 carat gold is stronger*

*allow gold is an alloy in 9 carat gold*

•        can change the colour

**2**

**[4]**

**Q3.**

(a)     (i)      many ethene / molecules / monomers

*accept double bonds open / break*

*accept addition polymerisation*

**1**

join to form a long hydrocarbon / chain / large molecule

*ignore references to ethane*

*correct equation gains* ***2*** *marks*

**1**

(ii)     (can be deformed but) return to their original shape (when heated or cooled)

*ignore ‘it remembers its shape’*

**1**

(iii)    cross links / extra bonds in PEX

*it = PEX throughout*

*accept inter-molecular bonds  
ignore inter-molecular forces*

**1**

molecules / chains in PEX are held in position

*accept rigid structure*

**1**

molecules / chains in PEX unable to slide past each other / move

**1**

(b)     any **four** from:

*ignore costs / sustainability / non-renewable*

•        less (hydrocarbon) fuels used

*allow less energy*

•        less / no electrical energy used

*allow no electrolysis*

•        reduce carbon / carbon dioxide emissions

*allow less global warming*

•        reduce / no pollution by sulfur dioxide / acid rain

*allow less / no transportation*

•        continuous process

•        conserve copper which is running out or only low-grade ores available

*allow less waste*

•        reduce the amount of solid waste rock that needs to be disposed

*allow less mining*

•        reduce the need to dig large holes (to extract copper ores)

**4**

**[10]**

**Q4.**

(a)     (i)      hydrogen

*must be name*

**1**

 (ii)    a line of four or more ethene molecules joined to the original two  
with single bonds

*at least two other ethene molecules joined to the original two in a chain gains* ***1*** *mark*

**2**

(b)     (i)      any **two** from:

•        non-biodegradable

*accept remains a long time*

•        landfill sites are filling up / limited

*accept land / space used up*

•        waste of a resource / could be recycled / reused

*ignore references to tablets / animals*

**2**

(ii)     any **one** from:

•        (two) different polymers / plastics / materials

•        need to be separated

•        limited collection points / many need to be collected

•        tablets may still be present

**1**

**[6]**

**Q5.**

(a)     1 × 10−2 g

**1**

(b)    

**1**

(test tube 1) 5.44 %

**and**

(test tube 2) 0.854 %

**1**

4.586

**1**

4.59

**1**

*allow ecf answer correctly calculated to 3 significant figures*

*allow 4.59 with no working for* ***4*** *marks*

*allow 4.586 with no working for* ***3*** *marks*

(c)     **Level 3 (5–6 marks):**

Detailed and coherent conclusions based on the evidence together with an evaluation  
are given in a response that is coherent and well-structured. A range of relevant points is made demonstrating a broad understanding of the key scientific ideas.

**Level 2 (3–4 marks):**

An attempt to relate relevant points and draw conclusions or to make an evaluation. The logic may be inconsistent at times but builds towards a coherent argument.

**Level 1 (1–2 marks):**

Simple descriptive statements are made. The logic may be unclear and any conclusions,  
if present, may not be consistent with the reasoning.

**0 marks:**

No relevant content.

**Indicative content**

Simple statements

•        nail rusted in test tubes 1 and 5

•        test tubes 1 and 4 contained air / oxygen and water

•        nail did not rust in test tubes 2, 3 and 4

•        test tube 2 no water present

•        test tube 3 no air / oxygen present

•        test tube 4 paint stopped rusting

•        test tube 6 scratched galvanised iron did not rust

•        test tube 6 galvanising stopped rusting

Conclusions

•        both water and oxygen are required for rusting

•        coatings that prevent water and oxygen reaching the metal prevent rusting

•        when paint is scratched, iron comes into contact with water and oxygen and the iron rusts

•        in test tube 5 less iron exposed so less rusting than in test tube 1

•        galvanising is better at resisting rusting than paint when scratched

•        zinc is more reactive than iron, so when galvanised metal is scratched, zinc reacts with water and oxygen first / sacrificially

Evaluation

•        oil and paint are effective at preventing rusting when the coating is intact

         galvanising is the most effective coating because it prevents rusting even  
when scratched.

**6**

(d)     iron + oxygen + water

*all three needed for* ***2*** *marks*

*2 correct =* ***1*** *mark*

*ignore air*

**2**

**[13]**

**Q6.**

(a)      79

**1**

79

**1**

(b)     hundred

**1**

(c)     (i)      electron(s)

**1**

(ii)     three

**1**

(d)     changes rate of reaction

*accept lowers activation energy*

**or**

speeds up / slows down reaction

*accept reduces costs*

**1**

(e)     (i)      melt

**1**

(ii)     crosslinking

*allow answers on diagram*

**or**

(covalent) bonds between polymers / chains

*allow bonds between layers  
do* ***not*** *allow intermolecular*

**1**

**[8]**

**Q7.**

(a)      (i)     2.5(kg)

*ignore units*

**1**

(ii)     40% (cement) **and** Test 3

*ignore units*

**1**

because it is anomalous or because it is much lower than the other  
two readings

*accept value not used to calculate mean*

*ignore outlier*

**1**

(iii)    as the percentage of cement increases the mass needed to break the  
sleeper increases

*allow ‘strength’ for ‘mass needed’*

*allow correct relationship using percentage of sand*

**1**

(iv)     volume/percentage / amount of water

*accept temperature*

**1**

(b)     any **two** from:

•        availability (of the raw materials)

•        cost of the raw materials

•        purity (of the raw materials)

**2**

**[7]**

**Q8.**

(a)     (i)      brown

**1**

(ii)     oxygen + iron + water      hydrated iron oxide / rust

*allow correct symbol equation*

*ignore oxidation numbers for product*

**1**

(b)     (i)      32.3

**1**

(ii)     7.6

*ecf from (b)(i)*

**1**

(iii)    do not know start volume of air

**1**

because the burette not graduated to the end

*allow iron wool takes up some of the space*

*if no other marks awarded accept all iron may have rusted (****1****)* ***or*** *still some oxygen left / not all used up (****1****)*

**1**

(c)     (i)      gains oxygen and water **or** oxygen and water are added

*allow reacts with or gains oxygen*

*allow reacts with or gains water*

*allow reacts with or gains elements which add to mass*

*ignore iron oxide forms*

**1**

(ii)     as temperature increases (from 10 °C to 42 °C or to 50 °C) the increase in mass of nail increases

*accept positive correlation*

*accept mass increases*

**1**

rate of increase gets faster as temperature goes up

*accept exponential  
ignore non linear*

**1**

no further increase at temperatures over 42 °C

*accept no further increase at high temperatures*

*exponential increase scores* ***2*** *marks*

**1**

(iii)    use a (bigger) flask **or** let air into the tube **or** leave for less time **or**

*ignore more water*

**1**

to make sure sufficient oxygen / air **or** not all oxygen used up

*accept converse*

*if no other marks awarded allow change in surface area for rusting* ***or*** *change in number of nails for* ***1*** *mark*

**1**

**[12]**

**Q9.**

(a)     2NH3

*allow NH3 with incorrect or missing balancing for* ***1*** *mark*

*allow multiples*

**2**

(b)     (i)      200

**1**

(ii)     rate of reaction (too) slow

*allow converse*

*ignore references to yield / cost*

**1**

(iii)    400

**1**

(iv)    lower yield

*allow converse*

*accept shifts equilibrium to left*

*allow favours the backward reaction*

*allow favours side with more (gaseous) molecules*

*allow lower rate*

**1**

(c)     (gases) cooled

*it = ammonia*

**1**

*ammonia* liquefied

*accept ammonia condensed*

*accept ammonia cooled below boiling point for* ***2*** *marks*

**1**

**[8]**

**Q10.**

(a)     alloy

**1**

(b)     in mixture:

*different sized / bigger atoms*

**1**

*so there are no layers / rows / lines (to slide)*

*accept converse*

**1**

(c)     any **two** from:

*ignore references to bend and mould*

•        cost

•        toxicity

•        strength

•        *appearance of brace*

•        *unreactive* ***or*** *resistant to corrosion / saliva*

*allow rusting as alternative to corrosion*

**2**

(d)     crosslinks

*allow lines / bonds between the rows / chains*

**1**

**[6]**

**Q11.**

(a)     all points correct

*±1 small square*

*allow 1 mark for 6 or 7 plots*

**2**

|  |  |
| --- | --- |
| Year | Percentage (%) of bottles made from other materials |
| 1975 | 5 |
| 1980 | 10 |
| 1985 | 22 |
| 1990 | 42 |
| 1995 | 70 |
| 2000 | 72 |
| 2005 | 90 |
| 2010 | 95 |

**1**

(b)     **Level 3 (5–6 marks):**

A detailed and coherent argument is provided which considers a range of issues and comes to a conclusion consistent with the reasoning.

**Level 2 (3–4 marks):**

An attempt to describe the advantages and disadvantages of the production and uses is made, which comes to a conclusion. The logic may be inconsistent at times but builds towards a coherent argument.

**Level 1 (1–2 marks):**

Simple statements made. The logic may be unclear and the conclusion, if present, may not be consistent with the reasoning.

**0 marks:**

No relevant content.

**Indicative content**

•        glass – 2 stages in production of soda-lime glass

•        glass – second stage, heating sand, limestone and sodium carbonate

•        HDPE – 3 stages in production

•        HDPE – second stage, cracking of naphtha to obtain ethene

•        HDPE – third stage, polymerisation of ethene

•        fewer stages in glass production, may be quicker

•        higher temperature in glass manufacture, therefore maybe higher energy requirement

•        glass bottle can be reused

•        consideration of collection / cleaning costs to reuse glass bottles

•        other glass products can be made from recycled glass

•        plastic has greater range of sizes

•        both produced from limited raw materials

•        higher percentage recycled materials in glass conserves raw materials

This indicative content is not exhaustive, other creditworthy

responses should be awarded marks as appropriate.

**6**

**[9]**

**Q12.**

(a)     endothermic

**1**

(b)     82 (%)

*correct answer with working gains* ***3*** *marks*

*if 17 or 34 not shown in working* ***max 2*** *marks*

*accept 82.4*

*accept 82.35 to full calculator display (82.35294...) correctly rounded to at least 2 sf*

*if no answer or incorrect answer, then*

*(Mr =) 17 gains* ***1*** *mark* ***or***

*14/17 gains* ***2*** *marks*

***OR***

*(2Mr =) 34 gains* ***1*** *mark* ***or***

*28/34 gains* ***2*** *marks*

***OR***

*14/their Mr shown gains* ***1*** *mark* ***or***

*correct calculation of 14/their Mr gains* ***2*** *marks*

**3**

(c)     (i)      7 / seven

**1**

(ii)     H+ + OH– → H2O

**1**

(iii)     ammonium chloride

*allow NH4Cl*

**1**

*ignore an incorrect formula*

(d)     Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also apply a ‘best-fit’ approach to the marking.

**Level 3 (5 – 6 marks):**

Suggestion with reasons from all three graphs, and linking of ideas which may explain a compromise.

**Level 2 (3 – 4 marks):**

Suggestion with reasons referring to more than one graph.

**Level 1 (1 – 2 marks):**

Suggestion with a reference to a graph.

**0 marks:**

No relevant content.

**Examples of chemistry points made in response:**

A reasonable suggested amount of fertiliser would be in the region of 200 kg (per ha).

Accept any suggestion from about 180 kg (per ha) to 500 kg (per ha).

**Yield:**

•        Using fertiliser improves yield.

•        Yield improved most up to about 200 kg (per ha) of fertiliser.

•        Yield only increased slightly above about 200 kg (per ha).

**Profit:**

•        About 200 kg of fertiliser gives the most profit.

•        Above about 200 kg (per ha) of fertiliser profit declines.

**Run off:**

•        Run off is at low levels until about 300 kg (per ha) of fertiliser.

•        Above about 300 kg (per ha) of fertiliser, run off increases.

**Examples of linking of ideas:**

•        Overall 200 kg gives high crop yield and most profit.

•        In conclusion 200 kg gives high crop yield and low run off.

•        200 kg gives most profit and low run off.

**Examples of compromise:**

•        Profits go down after about 200 kg (per ha) of fertiliser because cost of fertiliser is not covered by increased yield.

•        200 kg gives the highest profit although it is not the highest yield.

•        500 kg gives the best yield but has the most runoff.

**6**

**[13]**

**Q13.**

(a)     giant structure / lattice / layers / close packed

*first 3 marks can be obtained from a suitably labelled diagram*

*incorrect structure or bonding or particle = max 3*

**1**

made up of atoms / positive ions

**1**

with delocalized / free electrons

**1**

so electrons can move / flow through the metal

*accept so electrons can carry charge through the metal*

*accept so electrons can form a current*

**1**

(b)     an alloy (is a metal which) has different types / sizes of atoms

*accept converse for pure metal throughout*

*both marks can be obtained from suitable diagrams*

*allow made of different metals*

*allow mixture of metals / atoms / elements*

*ignore particles*

*ignore properties*

*do* ***not*** *accept compound*

**1**

alloy has distorted layers

*allow layers are unable to slide*

**1**

(c)     (i)      can return to its original shape

*accept shape memory alloy*

*accept smart alloy*

*ignore other properties*

**1**

(ii)     (pure copper is too) soft

*accept converse*

*accept malleable or bends*

*accept copper is running out*

*ignore references to strength and weakness*

**1**

(iii)    aluminium oxide

*accept alumina*

*accept Al2O3*

*ignore bauxite / aluminium ore*

**1**

(iv)    any **one** from:

•        different conditions

•        different catalyst

•        different pressure

*allow different concentration*

•        different temperature.

*do* ***not*** *accept different monomers*

**1**

(d)     any **two** from:

•        accurate

•        sensitive

•        rapid

•        small sample.

*both needed for 1 mark*

**1**

**[11]**

**Q14.**

(a)     (i)      natural gas

*allow fossil fuels / biogas generator*

**1**

(ii)     air contains oxygen

**1**

this would react with / oxidise the hydrogen

*allow this would react with / oxidise the iron*

*ignore nitrogen*

**1**

(iii)    cooled

**1**

ammonia condenses / liquefies (so can be separated)

**1**

nitrogen and hydrogen (remain as gases and) are returned to the reactor

*allow recycled*

**1**

(b)     (i)      200 °C **and** 1000 atmospheres

**1**

(ii)     the reaction is reversible

*allow stated as equilibrium or forward / backward reaction anywhere in answer*

**1**

forward reaction is exothermic so increased temperature lowers the yield of ammonia

*allow converse*

**1**

a lower temperature would decrease rate of reaction

*allow converse*

**1**

a higher pressure would increase the yield of ammonia because the forward reaction produces the least number of (gaseous) molecules / moles

*allow converse*

**1**

higher pressures would involve high cost / energy

**1**

*ignore risk / explosion*

**[12]**