**Questions**

**Q1.**The first stage in the manufacture of nitric acid is the oxidation of ammonia:

4NH3(g) + 5O2(g)  4NO(g) + 6H2O(g) Δ*H* = −906 kJ mol−1

(a)  In modern industrial plants this reaction is carried out at a pressure of around 3 atm. Which of the following statements is **incorrect**? The raised pressure

**(1)**

   **A**    helps push the reactants through the reactor.

   **B**    shifts the position of equilibrium to the right.

   **C**    increases the cost of the reactor.

   **D**    increases the energy cost of this part of the process.

(b)  A platinum-rhodium alloy catalyst is used in this reaction. Which of the following statements is **incorrect**? The catalyst

**(1)**

   **A**    lowers the activation energy of the reaction.

   **B**    has no effect on the equilibrium constant for the reaction.

   **C**    alters the enthalpy change of the reaction.

   **D**    reduces the energy cost of this part of the process.

(c)  The operating temperature of this reaction is about 900°C. The use of a high temperature

**(1)**

   **A**    increases the rate of the reaction and the equilibrium yield.

   **B**    increases the rate of the reaction and decreases the equilibrium yield.

   **C**    decreases the rate of the reaction and the equilibrium yield.

   **D**    decreases the rate of the reaction and increases the equilibrium yield.

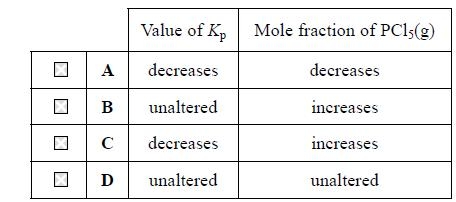
**(Total for Question = 3 marks)**

**Q2.**

Consider the equilibrium



Which of the following is true when the total pressure of the system is increased at  
 constant temperature?



**(Total for question = 1 mark)**

**Q3.**

At 100 °C, pure water has a pH of 6, whereas at 25 °C it has a pH of 7.  This is because

   **A**     the dissociation of water is endothermic, so the concentration of hydrogen  
                ions is lower at 100 °C than it is at 25 °C.

   **B**     the dissociation of water is exothermic, so the concentration of hydrogen ions  
                is lower at 100 °C than it is at 25 °C.

   **C**     the dissociation of water is endothermic, so the concentration of hydrogen  
                ions is higher at 100 °C than it is at 25 °C.

   **D**     at 100 °C, water has a higher concentration of hydrogen ions than of  
                hydroxide ions.

**(Total for question = 1 mark)**

**Q4.**An important step in the production of sulfuric acid is the oxidation of sulfur dioxide.

2SO2(g) + O2(g)  2SO3(g) Δ*H* = −196 kJ mol−1

Which of the conditions below is best suited to produce a high yield of sulfur trioxide, SO3?

   **A**    1 atm pressure and 800 °C.

   **B**    2 atm pressure and 800 °C.

   **C**    1 atm pressure and 400 °C.

   **D**    2 atm pressure and 400 °C.

**(Total for Question = 1 mark)**

**Q5.**(a)  For the equilibrium reaction between hydrogen and iodine

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

increasing the pressure of the system

**(1)**

   **A**    has no effect on the rate or the position of equilibrium.

   **B**    increases the rate but does not affect the position of equilibrium.

   **C**    increases the rate and shifts the equilibrium to the right.

   **D**    increases the rate and shifts the equilibrium to the left.

(b)  The equation for the equilibrium reaction between hydrogen and iodine may also be written as

½H2(g) + ½I2(g)  HI(g)

This change to the equation, compared to that in part (a),

**(1)**

   **A**    has no effect on the value of the equilibrium constant.

   **B**    halves the value of the equilibrium constant.

   **C**    doubles the value of the equilibrium constant.

   **D**    square roots the value of the equilibrium constant.

**(Total for Question = 2 marks)**

**Q6.**

1,2-dichloroethane decomposes in the presence of a catalyst.



Which of the following would result in an increase in the equilibrium yield of chloroethene?

   **A**     Increasing the temperature.

   **B**     Increasing the pressure.

   **C**     Increasing the surface area of the catalyst.

   **D**     Changing the catalyst to a more efficient one.

**(Total for question = 1 mark)**

**Q7.**

 Consider the equilibrium below.  
  
                                              CO(g) + Cl2(g)  COCl2(g)  
  
  (a) An increase in pressure by a factor of 2 will

**(1)**

   **A**      quadruple *K*p.

   **B**      double *K*p.

   **C**      have no effect on *K*p.

   **D**      halve *K*p.

(b) The units of *K*p are

**(1)**

   **A**      atm−2

   **B**      atm−1

   **C**      atm

   **D**      atm2

**(Total for question = 2 marks)**

**Q8.**

The Haber process is used to make ammonia from nitrogen and hydrogen at 450 °C.



(a) If the partial pressures of these gases were measured in atm, the units of the equilibrium constant *K*p will be

**(1)**

   **A**  atm

   **B**  atm2

   **C**  atm−2

   **D**  atm−1

(b) When the temperature of the system is increased

**(1)**

   **A**  *K*p decreases.

   **B**  *K*p increases.

   **C**  *K*p stays the same.

   **D**  *K*p first decreases and then increases.

**(Total for question = 2 marks)**

**Q9.**

Methane hydrate is found on continental shelves deep in oceans. It forms methane in an endothermic equilibrium reaction, which may be represented as



(a)  Which of the following changes would **decrease** the equilibrium yield of methane?

**(1)**

   **A**   Decreasing the temperature and decreasing the pressure.

   **B**   Increasing the temperature and decreasing the pressure.

   **C**   Decreasing the temperature and increasing the pressure.

   **D**   Increasing the temperature and increasing the pressure.

(b)  Which of the following would **increase** the value of the equilibrium constant, *K*p, for the above equilibrium?

**(1)**

   **A**   Decreasing the pressure

   **B**   Increasing the pressure

   **C**   Decreasing the temperature

   **D**   Increasing the temperature

**(Total for question = 2 marks)**

**Q10.**

Methane hydrate is found on continental shelves deep in oceans. It forms methane in an endothermic equilibrium reaction, which may be represented as



(a)  Which of the following changes would **increase** the equilibrium yield of methane?

**(1)**

   **A**    Increasing the temperature and decreasing the pressure.

   **B**    Decreasing both the temperature and the pressure.

   **C**    Increasing both the temperature and the pressure.

   **D**    Decreasing the temperature and increasing the pressure.

(b)  Which of the following would **decrease** the value of the equilibrium constant, *K*p, for the above equilibrium?

**(1)**

   **A**    Decreasing the pressure

   **B**    Increasing the pressure

   **C**    Decreasing the temperature

   **D**    Increasing the temperature

**(Total for question = 2 marks)**

**Q11.**Methanol is produced in the equilibrium reaction



Addition of more hydrogen to the equilibrium mixture at constant temperature

   **A**     increases the equilibrium yield of methanol.

   **B**     decreases the equilibrium yield of methanol.

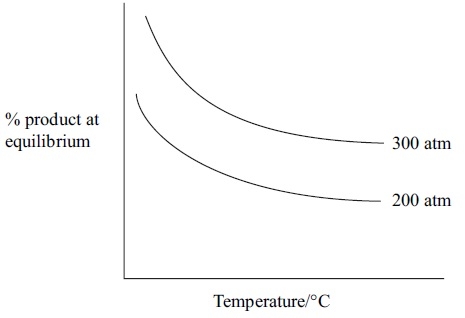
   **C**     increases the value of *K*p.

   **D**     decreases the value of *K*p.

**(Total for question = 1 marks)**

**Q12.**

The graph below shows the yield of product in a gaseous equilibrium at different  
 temperatures and pressures.



The forward reaction in the equilibrium is

   **A**    exothermic, and the number of moles of gas is increasing.

   **B**    endothermic, and the number of moles of gas is increasing.

   **C**    exothermic, and the number of moles of gas is decreasing.

   **D**    endothermic, and the number of moles of gas is decreasing.

**(Total for question = 1 mark)**

**Q13.**

 Which of these will **not** improve the **overall** yield of the Haber process?  
  
                         N2(g) + 3H2(g)  2NH3(g)       Δ*H* = −92kJ mol−1

   **A**      Increasing the pressure.

   **B**      Liquefying then removing the ammonia from the reaction.

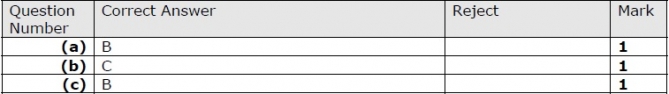
   **C**      Increasing the temperature.

   **D**      Recycling unreacted nitrogen and hydrogen.

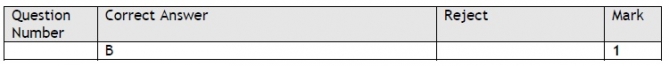
**(Total for question = 1 mark)**

**Mark Scheme**

**Q1.**



**Q2.**



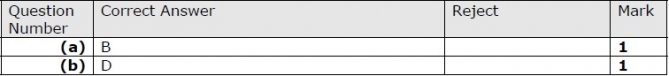
**Q3.**



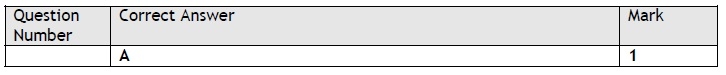
**Q4.**



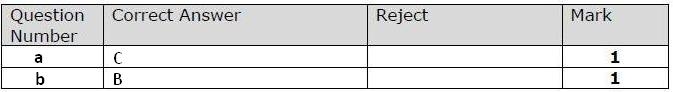
**Q5.**



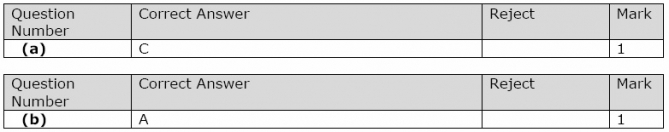
**Q6.**



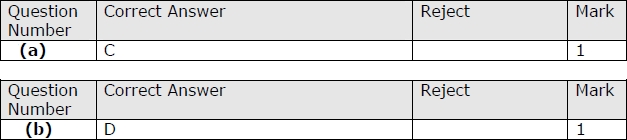
**Q7.**



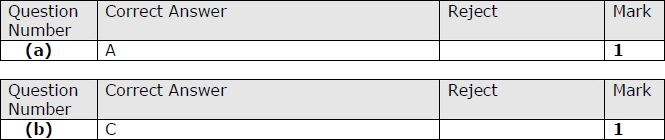
**Q8.**



**Q9.**



**Q10.**



Q11.  


**Q12.**



**Q13.**

