Chemistry

Unit 4

Area of Study 4 Test Answers:

Industrial chemistry

Section 1: Multiple choice (12 marks)

Question 1

C HCl is the limiting reagent and 3 moles of H2 gas are produced.

Question 2

B A catalyst increases the reaction rate but has no effect on the equilibrium yield. As the reaction is exothermic, the equilibrium yield is reduced by a temperature increase.

Question 3

D A catalyst lowers the activation energy of a reaction so that molecules require less energy for successful collisions. An increase in temperature has no effect on the activation energy; however, the average kinetic energy of molecules increases and so a higher proportion will have sufficient energy for successful collisions.

Question 4

B Reaction II is exothermic so lower temperatures favour the formation of products. There are 3 moles on the left-hand side of the equation and 2 moles on the right, so an increase in pressure will favour product formation.

Question 5

D 46.3%

Question 6

B An excess of oxygen is used to drive the equilibrium position to the right, favouring the formation of sulfur trioxide.

End of section 1

Section 2: Short answer (14 marks)

\* Indicates 1 mark

Question 7 (4 marks)

Ammonia is a polar molecule, with hydrogen bonds between its molecules, as well as dispersion forces.\*

Nitrogen and hydrogen are non-polar molecules and therefore have only dispersion forces between their molecules.\*

Therefore, ammonia has a much higher boiling point than nitrogen and hydrogen.\*

This means that it will condense from a gas to a liquid at a higher temperature, allowing it to be removed as a liquid, while nitrogen and hydrogen remain as gases.\*

Question 8 (5 marks)

a 2Mg (s) + O2(g) → 2 MgO(s)\*

b n(Mg) = 

 =

 = 0.1644 moles\*

 Theoretical n(MgO) = n(Mg)

 = 0.1644 moles\*

 Theoretical m(MgO) = n × M

 = 0.1644 × 40.31

 = 6.627 g\*

 Percentage yield = 

 = 85.9%\*

Question 9 (5 marks)

n (KClO4) = 

 = 7218 moles\*

n(KClO3) = 

 = 9623 moles\*

n(KClO) = 

 = 28 870 moles\*

n(Cl2) = 

 = 41243 moles\*

V(Cl2) 

 = 

 = 895 000 L\*

End of section 2

Section 3: Extended answer (19 marks)

\* Indicates 1 mark

Question 10 (12 marks)

a Step 1 S(s) + O2(g) → SO2(g)\*

 Step 2: 2SO2 + O2 (g) → 2 SO3(g)\*

 Step 3: SO3(g) + H2SO4(l) → H2S2O7(l)\*

 Step 4: H2S2O7(l) + H2O(l) → H2SO4(l)\*

b Rate:

 High rate is favoured by a high temperature, to increase the frequency of the collisions between O2 and SO2, as well as the proportion of collisions with sufficient energy to react.

 High rate is also favoured by a high pressure, which increases the frequency of collisions between the reactants. (2 marks)

 Yield:

 High yield is favoured by a low temperature. The forward reaction is exothermic. This means that according to Le Châtelier’s principle, the forward reaction will be favoured at low temperatures.

 High yield is favoured by a high pressure. This is because the molar ratio of reactants to products is 3:2. The forward reaction is favoured at high pressures, because it results in a lower number of gaseous molecules, decreasing the overall pressure within the system. (4 marks)

 Conditions used:

 In practice, a moderate temperature of 400–500°C is used together with a catalyst. This is a compromise and ensures that a high yield is produced at a high enough rate. \*

 Although both rate and yield are favoured by high pressures, the cost of maintaining a high pressure is too high to make this economical. Therefore atmospheric pressure is used.\*

Question 11 (7 marks)

a n(FeS2) = 

 = 

 = 0.02442 moles \*

 n(O2) = 

 = 

 = 0.0881 moles\*

 1 mole of iron pyrite requires 3.75 moles of O2 to react completely.

 0.02442 moles of iron pyrite requires 0.091575 moles of O2 to react completely.

 The number of moles of O2 required is greater than the number of moles of O2 present.\*

 Therefore, O2 is the limiting reagent.\*

b n(Fe(OH)3) = n(O2) 

 = 

 = 0.0235\*

 m(Fe(OH)3) = n × M

 = 0.0235 × 106.874

 = 2.5 g (1 + 1 mark for 2 sf)

End of answers