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 H_2 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

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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 $2Mg (s) + O_2(g) \rightarrow 2 MgO(s)$*

b $n(\text{Mg}) = \frac{m}{M}$

$= \frac{4}{24.31}$

= 0.1644 moles*

Theoretical n(MgO) = n(Mg)

= 0.1644 moles*

Theoretical m(MgO) = $n \times M$

= 0.1644×40.31

= 6.627 g*

Percentage yield = $\frac{5.69}{6.627 \times 100}$

= 85.9%*

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Question 9 **(5 marks)**

$n\ (KClO_4) = \dfrac{1000\,000}{138.55}$

$= 7218$ moles*

$n(KClO_3) = \dfrac{7218 \times 4}{3}$

$= 9623$ moles*

$n(KClO) = \dfrac{9623 \times 3}{1}$

$= 28\,870$ moles*

$n(Cl_2) = \dfrac{28\,870 \times 100}{70}$

$= 41243$ moles*

$V(Cl_2) = \dfrac{nRT}{P}$

$= \dfrac{41\,243 \times 8.314 \times 313.1}{120}$

$= 895\,000$ L*

End of section 2

Section 3: Extended answer (19 marks)

*** Indicates 1 mark**

Question 10 **(12 marks)**

a Step 1 $S(s) + O_2(g) \rightarrow SO_2(g)$*

Step 2: $2SO_2 + O_2\ (g) \rightarrow 2\ SO_3(g)$*

Step 3: $SO_3(g) + H_2SO_4(l) \rightarrow H_2S_2O_7(l)$*

Step 4: $H_2S_2O_7(l) + H_2O(l) \rightarrow H_2SO_4(l)$*

b Rate:

High rate is favoured by a high temperature, to increase the frequency of the collisions between O_2 and SO_2, 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 $n(FeS_2) = \frac{m}{M}$

$= \frac{2.93}{119.97}$

$= 0.02442$ moles *

$n(O_2) = \frac{V}{22.71}$

$= \frac{2.0}{22.71}$

$= 0.0881$ moles*

1 mole of iron pyrite requires 3.75 moles of O_2 to react completely.

0.02442 moles of iron pyrite requires 0.091575 moles of O_2 to react completely.

The number of moles of O_2 required is greater than the number of moles of O_2 present.*

Therefore, O_2 is the limiting reagent.*

b $n(Fe(OH)_3) = n(O_2) \times \frac{4}{15}$

$= \frac{0.881 \times 4}{15}$

$= 0.0235$*

$m(Fe(OH)_3) = n \times M$

$= 0.0235 \times 106.874$

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

End of answers

