

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

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.*

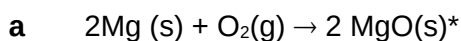
Nitrogen and hydrogen are non-polar molecules and therefore have only dispersion forces between their molecules.*

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)



b
$$n(\text{Mg}) = \frac{m}{M}$$
$$= \frac{4}{24.31}$$
$$= 0.1644 \text{ moles*}$$

Theoretical $n(\text{MgO}) = n(\text{Mg})$
 $= 0.1644 \text{ moles*}$

Theoretical $m(\text{MgO}) = n \times M$
 $= 0.1644 \times 40.31$
 $= 6.627 \text{ g*}$

Percentage yield = $\frac{5.69}{6.627} \times 100$
 $= 85.9\%*$

Question 9**(5 marks)**

$$n(\text{KClO}_4) = \frac{1000\,000}{138.55}$$

$$= 7218 \text{ moles}^*$$

$$n(\text{KClO}_3) = \frac{7218 \times 4}{3}$$

$$= 9623 \text{ moles}^*$$

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

$$= 28\,870 \text{ moles}^*$$

$$n(\text{Cl}_2) = \frac{28\,870 \times 100}{70}$$

$$= 41243 \text{ moles}^*$$

$$V(\text{Cl}_2) = \frac{nRT}{P}$$

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

$$= 895\,000 \text{ L}^*$$

End of section 2

Section 3: Extended answer

(19 marks)

* Indicates 1 mark

Question 10

(12 marks)

a Step 1 $\text{S(s)} + \text{O}_2\text{(g)} \rightarrow \text{SO}_2\text{(g)}^*$

Step 2: $2\text{SO}_2 + \text{O}_2\text{(g)} \rightarrow 2\text{SO}_3\text{(g)}^*$

Step 3: $\text{SO}_3\text{(g)} + \text{H}_2\text{SO}_4\text{(l)} \rightarrow \text{H}_2\text{S}_2\text{O}_7\text{(l)}^*$

Step 4: $\text{H}_2\text{S}_2\text{O}_7\text{(l)} + \text{H}_2\text{O(l)} \rightarrow \text{H}_2\text{SO}_4\text{(l)}^*$

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
$$n(\text{FeS}_2) = \frac{m}{M}$$
$$= \frac{2.93}{119.97}$$
$$= 0.02442 \text{ moles}^*$$

$$n(\text{O}_2) = \frac{V}{22.71}$$
$$= \frac{2.0}{22.71}$$
$$= 0.0881 \text{ moles}^*$$

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
$$n(\text{Fe}(\text{OH})_3) = n(\text{O}_2) \times \frac{4}{15}$$
$$= \frac{0.881 \times 4}{15}$$
$$= 0.0235^*$$

$$m(\text{Fe}(\text{OH})_3) = n \times M$$
$$= 0.0235 \times 106.874$$
$$= 2.5 \text{ g}$$

(1 + 1 mark for 2 sf)

End of answers