Reversible Reacts + Dynamic Equilibrium

Question Paper 1

Level	GCSE (9-1)
Subject	Combined Science: Trilogy - Chemistry
Exam Board	AQA
Topic	5.6 Rate + Extent Chemical Change
Sub-Topic	Reversible Reacts + Dynamic Equilibrium
Difficulty Level	Gold Level
Booklet	Question Paper 1

Time Allowed: **49 minutes**

Score: **/48**

Percentage: **/100**

Grade Boundaries:

Q1. Sulfur dioxide (SO_2) is used to manufacture sulfuric acid.

(a) Explain why sulfur dioxide has a low boiling point.

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(3)

(b) The equation shows one stage in the manufacture of sulfuric acid from sulfur dioxide.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The reaction is exothermic in the forward direction.

Use Le Chatelier's Principle to predict the effect of increasing the temperature on the amount of sulfur trioxide (SO_3) produced at equilibrium.

Give a reason for your answer.

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(2)

(c) Use Le Chatelier's Principle to predict the effect of increasing the pressure on the amount of sulfur trioxide (SO_3) produced at equilibrium.

Give a reason for your answer.

(2)
(Total 7 marks)

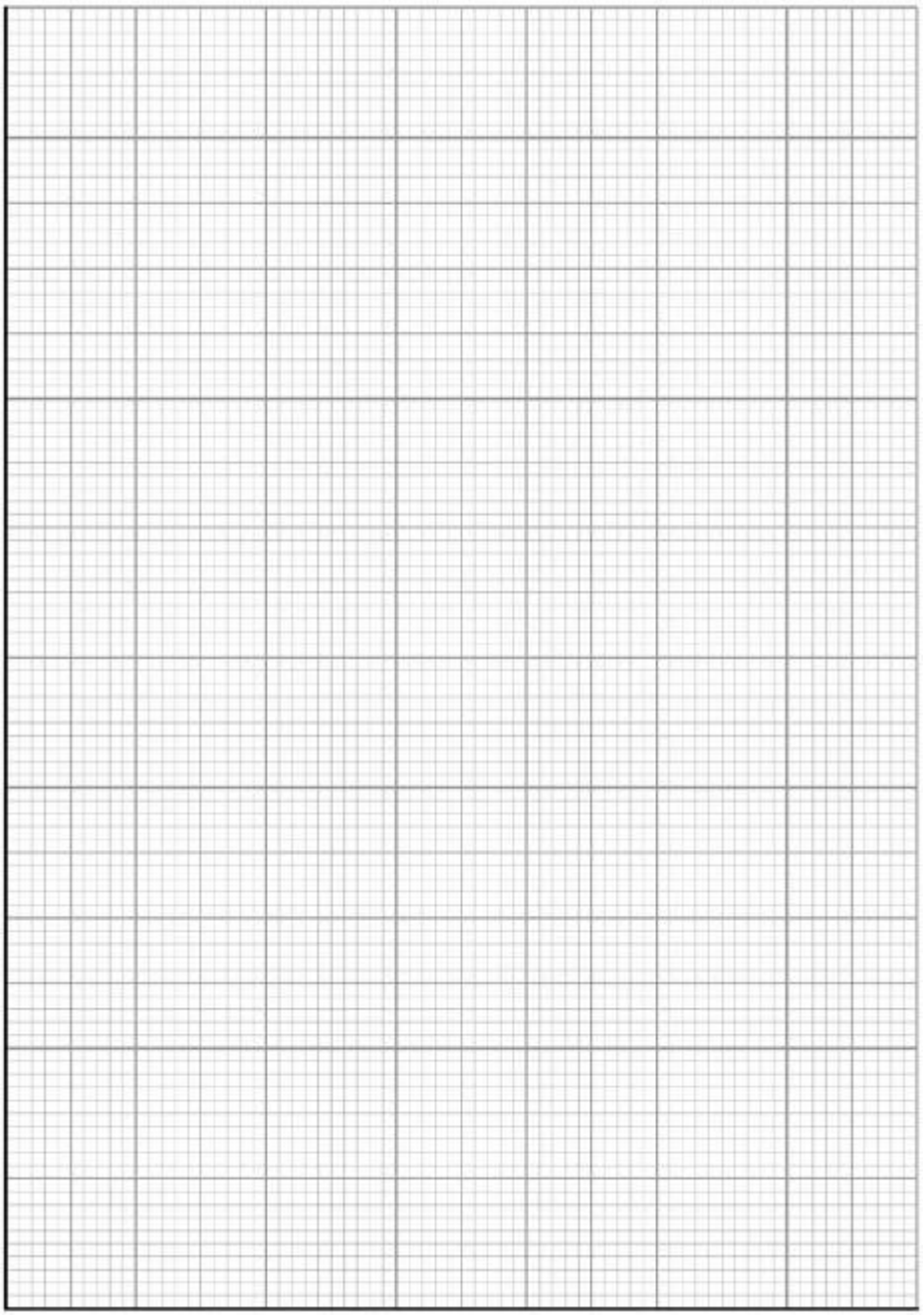
Q2. Ammonium nitrate (NH_4NO_3) is produced by reacting ammonia with nitric acid.

A student measured the mass of ammonium nitrate that dissolves in 100 cm^3 of water at different temperatures.

The table below shows the student's results.

Temperature in °C	0	20	40	60	80	100
Mass of ammonium nitrate in g that dissolves in 100 cm^3 water	119	190	286	321	630	1 024

(a) Use the table above to plot a graph of the solubility of ammonium nitrate on the figure below.



(4)

(b) At 20 °C, 190 g of ammonium nitrate dissolves in 100 cm^3 of water.

Calculate the amount of ammonium nitrate (in moles) that dissolves in 1 dm^3 of water at 20 °C.

Relative atomic masses (A_r): H = 1; N = 14; O = 16

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Amount of dissolved ammonium nitrate = ... mol

(3)

(c) Farmers use ammonium nitrate as a fertiliser.

Farmers want to slow down the rate at which ammonium nitrate fertiliser dissolves in the water in the soil.

Suggest why they spread the fertiliser in the form of small beads instead of a fine powder.

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(2)

(d) Ammonia is needed to make ammonium nitrate.

The reaction used to make ammonia is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The forward reaction is exothermic.

At equilibrium, about 35% of the nitrogen and hydrogen are converted to ammonia at
450 °C and 200 atmospheres pressure.

Explain the effects of increasing the temperature, or increasing the pressure, on the amount of ammonia produced at equilibrium.

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(4)
(Total 13 marks)

Q3. A company manufactures ethanol (C_2H_5OH).

The reaction for the process is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45 \text{ kJ per mole}$$

The temperature and pressure can be changed to increase the yield of ethanol at equilibrium.

(a) Explain what is meant by equilibrium.

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(3)

(b) (i) How would increasing the temperature change the **yield** of ethanol at equilibrium?

Give a reason for your answer.

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(2)

(ii) How would increasing the pressure change the **yield** of ethanol at equilibrium?

Give a reason for your answer.

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(2)

(c) A catalyst is added to increase the rate of the reaction.

Explain how adding a catalyst increases the rate of a chemical reaction.

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(2)
(Total 9 marks)

Q4. The equation for a reaction to produce hydrogen is:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

(a) Explain why changing the pressure does **not** affect the yield of hydrogen at equilibrium.

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(1)

(b) Suggest why the best yield of hydrogen at equilibrium is obtained at **low** temperatures.

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(1)

(c) The temperature used in industry needs to be high enough for the reaction to take place quickly. Explain, in terms of particles, why the rate of reaction increases when the temperature is increased.

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(3)

(d) Scientists have developed catalysts which allow the reaction to take place quickly at lower temperatures. How could this be good for the manufacturer and for the environment?

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(2)
(Total 7 marks)

Q5. Methanol is a fuel that is used in some racing cars instead of petrol.

Methanol can be made from carbon monoxide and hydrogen. The equation for this reaction is shown below.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

The forward reaction is exothermic.

(a) A high pressure (between 50 and 100 atmospheres) is used in this process.

Explain why the highest equilibrium yield of methanol is obtained at high pressure.

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(1)

(b) The temperature used in this process is about 250 °C.

It has been stated that, 'the use of this temperature is a compromise between the equilibrium yield of product and the rate of reaction'.

Explain this statement.

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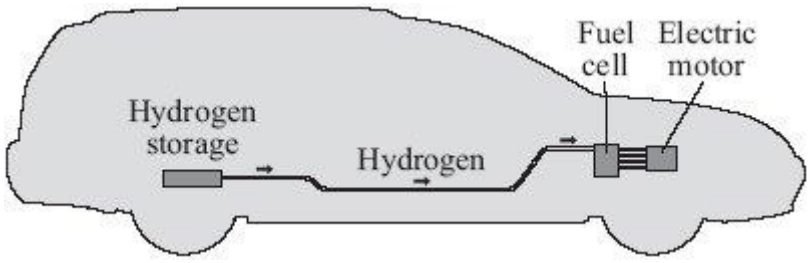
(3)
(Total 4 marks)

Q6. Read the article and then answer the questions that follow.

Hydrogen fuel for cars?



Hydrogen is an excellent fuel. It can be made by the electrolysis of potassium hydroxide solution.

Hydrogen gas can be stored under pressure in a cylinder but a leak of the gas could cause an explosion.

It has been found that lithium nitride can absorb and then release large volumes of hydrogen. A chemical reaction takes place between the hydrogen and the lithium nitride. The hydrogen is held in the resulting compounds by chemical bonds.

The problem is that the rate at which hydrogen is absorbed and then released from normal sized particles of lithium nitride is slow.

Recently scientists have made 'nanosized' particles of lithium nitride. These particles absorb hydrogen in the same way as normal sized lithium nitride particles. The 'nanosized' particles have the advantage that they absorb and release the hydrogen much faster when needed in the fuel cell.

It is hoped that 'nanosized' particles of lithium nitride may provide a safe method of storing hydrogen in the future.

(a) Hydrogen is produced at the negative electrode during the electrolysis of potassium hydroxide solution.

(i) Why are hydrogen ions attracted to the negative electrode?

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(1)

(ii) Potassium ions are also attracted to the negative electrode.

Explain why hydrogen gas is formed but not potassium.

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(1)

(b) Lithium nitride is made by reacting lithium with nitrogen.

Balance the equation for this reaction.

..... $Li + N_2 \rightarrow$ ..... Li_3N

(1)

(c) (i) The equation for the reaction of lithium nitride with hydrogen is:

$$Li_3N + 2H_2 \rightleftharpoons LiNH_2 + 2LiH$$

What feature of this reaction allows the hydrogen to be released?

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(1)

(ii) Hydrogen stored in a fuel tank filled with lithium nitride would be safer in an accident than a cylinder full of hydrogen.

Suggest and explain why.

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(2)

(d) Lithium nitride is an ionic compound which contains lithium ions (Li^+) and nitride ions (N^{3-}).

(i) The formation of a lithium ion from a lithium atom is an oxidation reaction.

Explain why.

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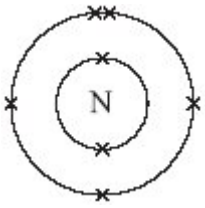
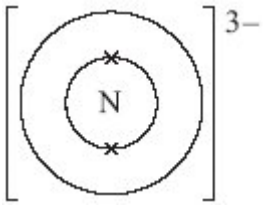
(1)

(ii) The diagram shows the electronic structure of a nitrogen atom.



Complete the diagram below to show the electronic structure of a nitride ion (N^{3-}).



(1)

(Total 8 marks)