Neap:

Trial Examination 2011

VCE Chemistry Unit 2

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Student's Name: _____

Teacher's Name: _____

Structure of Booklet

Section	Number of questions	Number of questions to be answered	Marks
A Multiple-choice	20	20	20
B Short-answer	5	5	55
			Total 75

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied

Question and answer booklet of 16 pages, with a detachable data booklet in the centrefold.
Answer sheet for multiple-choice questions.

Instructions

Detach the data booklet from the centre of this booklet during reading time.
Please ensure that you write **your name** and your **teacher's name** in the space provided on this booklet and in the space provided on the answer sheet for multiple-choice questions.
All written responses must be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet and hand them in.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

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SECTION A: MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

Question 1

Which of the following shows the volume of water, in mL, which must be added to 150 mL of a 0.340 M NaCl solution in order to produce a 0.204 M NaCl solution?

A. 54
B. 90
C. 100
D. 250

Question 2

A 50 mL sample of chlorine gas is held in a container at 100 kPa and 20°C. The volume of the container is increased by 50 mL and the temperature is increased to 40°C.

The final pressure, in kPa, in the container is closest to

A. 50
B. 100
C. 150
D. 200

Question 3

A strip of lead is placed in an acidified solution of nickel(II) nitrate.

Which of the following would be expected to occur?

A. The green colour of the nickel solution fades.
B. Bubbles of colourless, odourless gas form.
C. A precipitate of lead(II) nitrate forms.
D. The mass of the lead strip increases.

Question 4

Calcium hydroxide solution reacts with carbon dioxide gas according to the equation:

$$Ca(OH)_2(aq) + 2CO_2(g) \rightarrow Ca(HCO_3)_2(aq)$$

What is the maximum volume of carbon dioxide gas, in litres at SLC, which will react completely with 500.0 mL of a 0.0200 M solution of calcium hydroxide?

A. 0.245
B. 0.490
C. 245
D. 490

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The following information relates to Questions 5 and 6.

Phosphoric acid (H_3PO_4) ionises partially in water in three separate reactions. The extent of ionisation decreases progressively as each proton is donated.

Question 5

Which of the following shows the relative number of each chemical species in 500 mL of a 1.0 M phosphoric acid solution, in order from lowest to highest?

A. $H_3O^+ < HPO_4^{2-} < H_2O < PO_4^{3-}$

B. $PO_4^{3-} < H_3PO_4 < H_2PO_4^- < H_2O$

C. $HPO_4^{2-} < PO_4^{3-} < H_2O < H_3O^+$

D. $HPO_4^{2-} < H_2PO_4^- < H_3PO_4 < H_2O$

Question 6

Which of the following statements are correct when comparing 1.0 M solutions of HCl and H_3PO_4?

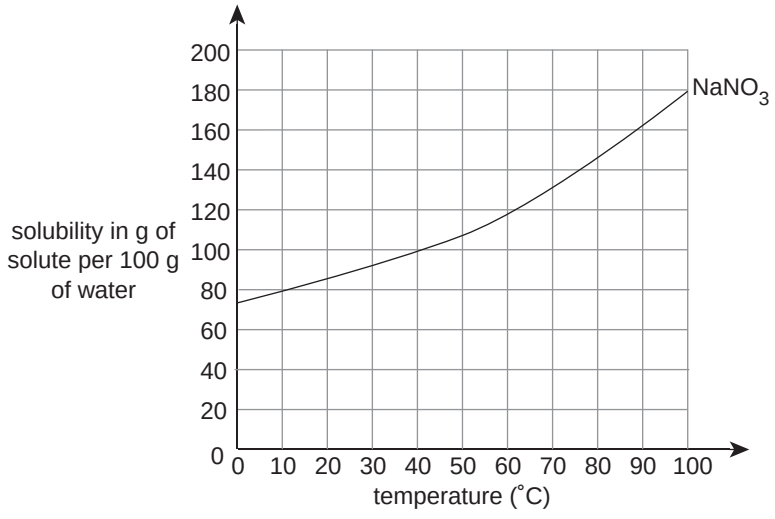
I Both acid solutions will have the same pH.

II 10 mL of the acid solutions will each require 10 mL of a 1.0 M NaOH solution for neutralisation.

A. I only
B. II only
C. I and II
D. neither I nor II

Question 7

The graph below shows the solubility curve for $NaNO_3$.



70 mL of a saturated solution of $NaNO_3$ was cooled from 90°C to 40°C.

The mass of $NaNO_3$ (in grams) expected to crystallise from the solution is closest to

A. 40
B. 60
C. 70
D. 100

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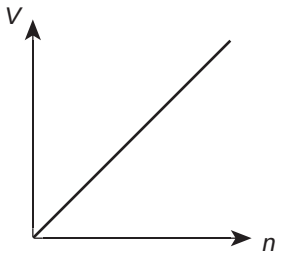
Question 8

Which of the following graphs represents the behaviour of an ideal gas?

A.



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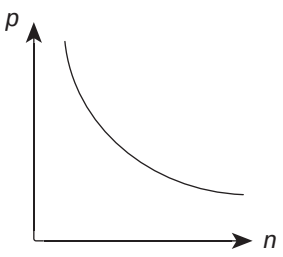

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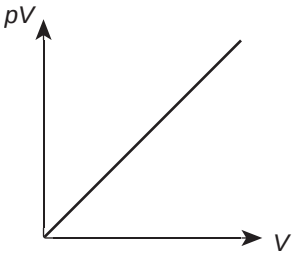
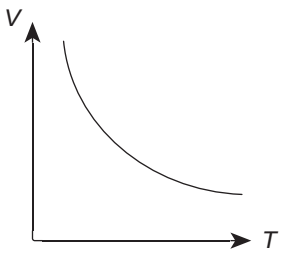


D.



Question 9

Under certain conditions, the pH of pure water is 7.5.

This means that

A. the concentration of hydroxide ions in the water is $10^{-6.5}$ M.

B. this is a neutral solution as it is pure water.

C. there is a greater number of hydroxide ions present than hydronium ions.

D. the water is alkaline as the pH is greater than 7.

Question 10

When 120 mL of hydrogen chloride gas is mixed with 50 mL of oxygen gas, a reaction occurs as shown by the following equation.

$$4HCl(g) + O_2(g) \rightarrow 2H_2O(g) + 2Cl_2(g)$$

If the temperature and pressure are constant, the final gas volume (in mL) will be

A. 100

B. 120

C. 140

D. 170

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Question 11

The kinetic molecular theory of gases includes which of the following statements?

I There are significant forces of attraction and repulsion between gas particles.

II Collisions between gas particles are elastic, i.e. energy is not lost during collisions.

III The average kinetic energy of the particles in a gas sample is proportional to the pressure of the gas.

IV The spaces between gas particles are large in comparison to the size of the gas particles.

A. II and III only
B. II and IV only
C. II, III and IV only
D. I, II, III and IV

The following information relates to Questions 12 and 13.

An experiment was conducted to determine the reactivity series for metals P, Q, R and S by examining any reactions which occur between the metals and solutions of the metal ions. Some of the results of the experiment were:

- Metal P reacts with metal ion S^{2+} but not with metal ion Q^{2+}
- Metal Q reacts with metal ion S^{2+} but not with metal ion R^{2+}

Question 12

Which of the following identifies the decreasing reactivity of these metals, starting with the most reactive metal?

A. Q, P, S, R
B. R, Q, P, S
C. S, Q, P, R
D. Q, R, S, P

Question 13

A galvanic cell is constructed using the P^{2+}/P and R^{2+}/R half-cells.

Which of the following shows the expected reaction at the anode of this galvanic cell?

A. $R(s) \rightarrow R^{2+}(aq) + 2e^-$

B. $P(s) \rightarrow P^{2+}(aq) + 2e^-$

C. $R^{2+}(aq) + 2e^- \rightarrow R(s)$

D. $P^{2+}(aq) + 2e^- \rightarrow P(s)$

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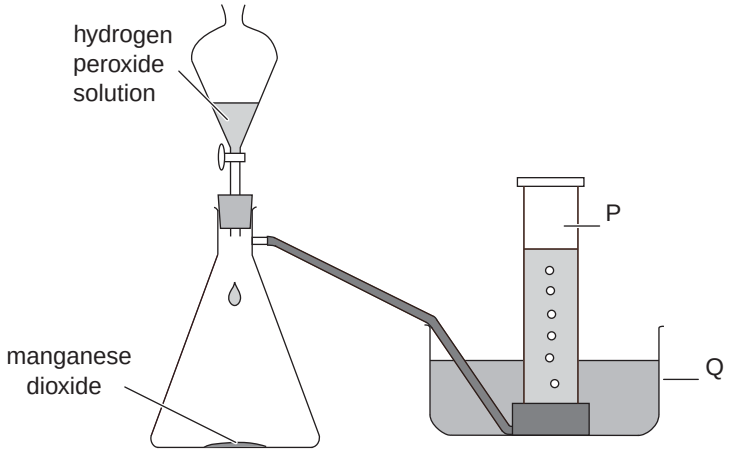
Question 14

Oxygen gas may be prepared in the laboratory using the chemicals and equipment shown below. The reaction may be represented by the equation:

$$2H_2O_2(aq) \xrightarrow{MnO_2} 2H_2O(l) + O_2(g)$$



Which one of the following statements about this preparation of oxygen is accurate?

A. The gas pressure recorded in cylinder P is due to the pressure of oxygen gas only.

B. The level of water in trough Q will remain constant throughout the preparation of the oxygen gas.

C. Increasing the concentration of hydrogen peroxide will increase the rate at which the oxygen gas is collected.

D. Oxygen is prepared industrially using a larger scale arrangement of the same equipment.

Question 15

A flask contains 1.0 g of oxygen gas at a temperature of 70°C. An identical flask contains 1.0 g of nitrogen gas at a temperature of 70°C.

In comparison to the nitrogen containing flask, the oxygen containing flask holds

A. more molecules, and they have a greater average velocity.

B. more molecules, and they have a lower average velocity.

C. less molecules, and they have a greater average velocity.

D. less molecules, and they have a lower average velocity.

Question 16

An important reaction in the rusting of iron is shown by the chemical equation:

$$2Fe(s) + O_2(aq) + 2H_2O(l) \rightarrow 2Fe^{2+}(aq) + 4OH^-(aq)$$

Which action is **least** likely to prevent the rusting of a piece of iron?

A. coating the iron with a layer of manganese

B. connecting the iron to the negative terminal of a direct current power supply

C. drying the air which surrounds the iron metal

D. using a wire to connect the iron to a piece of tin

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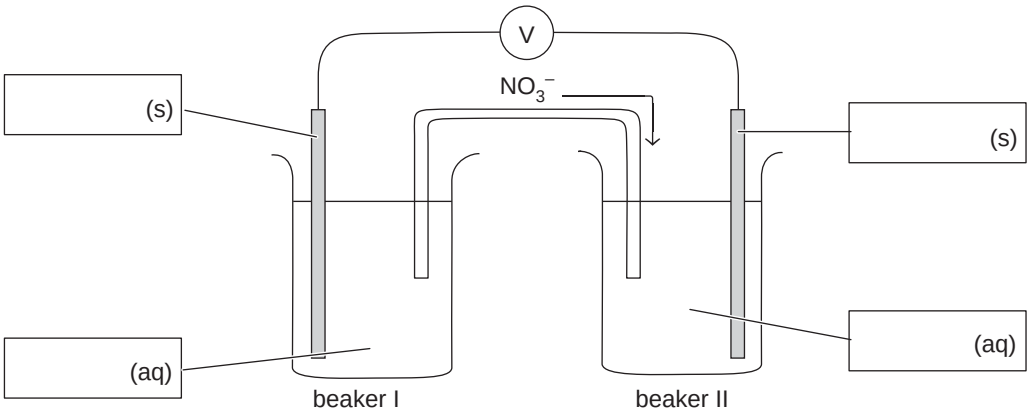
The following information relates to Question 17 and 18.

An electrochemical cell used to produce an electric current was constructed using two standard half-cells $Pb^{2+}(aq)/Pb(s)$ and $Fe^{2+}(aq)/Fe(s)$. The two half-cells were joined by an inverted U-tube containing a solution of sodium nitrate. The arrangement is shown in the diagram below



It was found that when a current was generated, nitrate ions from the salt bridge flowed into Beaker II, as shown in the diagram above.

Question 17

The species reacting in beaker I when the current is flowing is

A. Fe(s)

B. Pb(s)

C. $Pb^{2+}(aq)$

D. $Fe^{2+}(aq)$

Question 18

The electrode in Beaker II in this galvanic cell is

A. the positively charged anode.

B. the positively charged cathode.

C. the negatively charged anode.

D. the negatively charged cathode.

Question 19

A sealed flask contains 0.108 g of a hydrocarbon compound at 150°C and 100 kPa. An identical flask under the same conditions contains 0.042 g of nitrogen gas.

The molecular formula of the hydrocarbon is

A. C_4H_8

B. C_4H_{10}

C. C_5H_{10}

D. C_5H_{12}

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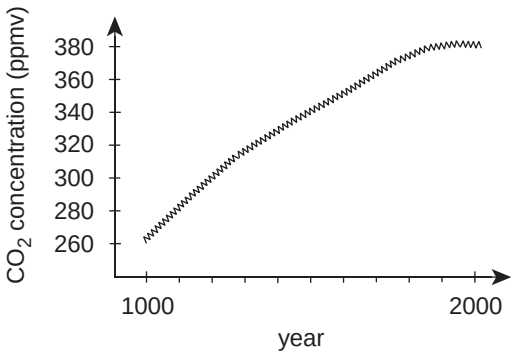
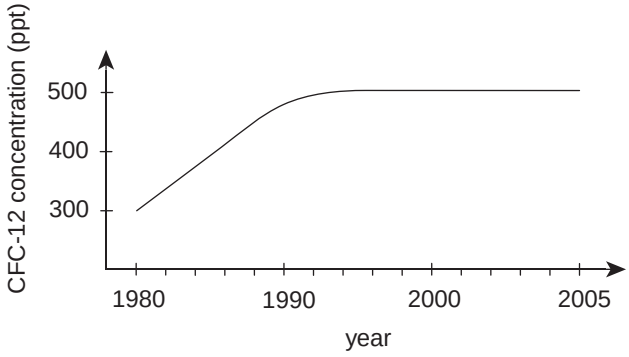
Question 20

Which of the following graphs incorrectly shows the relationship between an atmospheric quantity and a location or time?

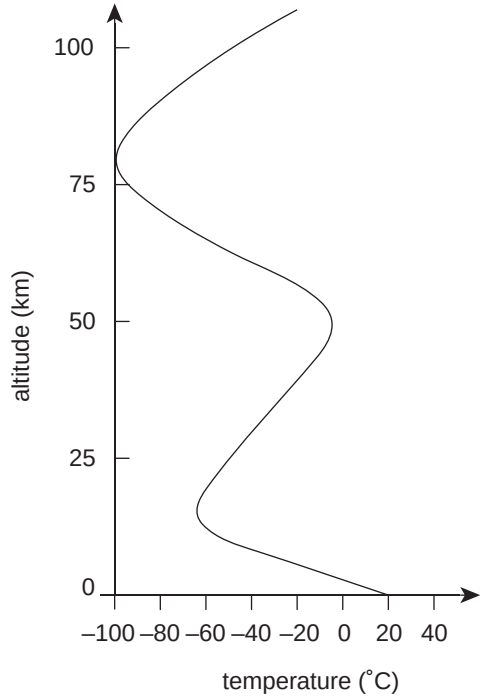
A.



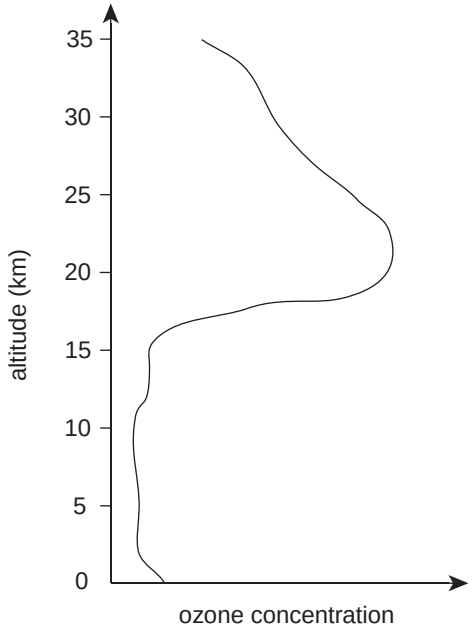
B.



C.



D.



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SECTION B: SHORT-ANSWER QUESTIONS

Instructions for Section B

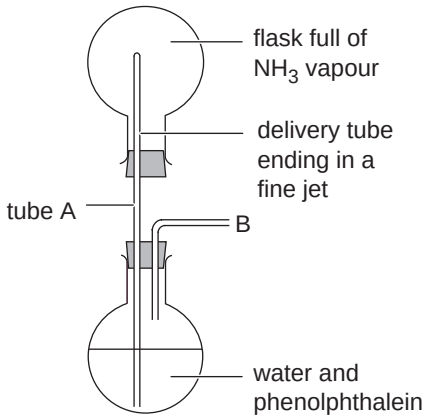
Answer **all** questions in the spaces provided.

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example $H_2(g)$; NaCl(s).

Question 1

A demonstration of the behaviour of certain gases is the 'fountain experiment'. The diagram below shows the equipment used. Phenolphthalein, an acid-base indicator, turns pink in solutions of pH above 9.



By blowing gently in the tube at point B to increase the gas pressure in the lower flask, some water is forced up tube A into the upper flask. Immediately, a fountain of pink-coloured water sprays into the upper flask. The spray continues until the lower flask is empty.

a. i. Explain why the fountain occurred when a small amount of water was introduced into the upper flask.

_____

_____

_____

_____

_____

ii. With the aid of a balanced chemical equation, explain why the fountain water was pink-coloured.

_____

_____

_____

_____

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iii. Initially, the 250.0 mL upper flask contained ammonia vapour at 20°C with a pressure of 1.00×10^5 Pa.

Calculate the mass of ammonia, in grams, in the upper flask.

_____

_____

_____

_____

2 + 2 + 3 = 7 marks

b. The 'fountain experiment' relies on the high solubility of ammonia gas in water which is 75.1 L in 100 mL of water at 20°C. The solubilities, in water, of two other gases are shown in the table below.

Gas	**Solubility of gas (mL per 100 mL of water)**		
	0°C	**20°C**	**40°C**
oxygen	4.8	3.3	2.5
sulfur dioxide	7980	4250	2170

i. Using a labelled diagram, including the structural formulas of ammonia and water molecules, explain how ammonia dissolves in water.

_____

_____

_____

ii. Describe an environmental problem caused by the high solubility of sulfur dioxide in water.

_____

_____

_____

_____

iii. Some industries produce heated waste water.

With reference to the information in the table of gas solubilities, explain the environmental problem caused by returning this heated water to natural waterways.

_____

_____

_____

_____

3 + 2 + 2 = 7 marks

Total 14 marks

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Question 2

a. The list below shows a number of atoms, molecules and ions. Select from this list when answering the questions which follow.

Cu^{2+}	NO_2	Ar	H_2O	NO	CO_2	Ne
Ag	OH^-	N_2	Ca^{2+}	NO_3^-	He	Ca

Select from the list above

i. a pair of substances which would react to form a gas

_____

ii. two species which make up a conjugate acid-base pair

_____

iii. the most abundant noble gas in the atmosphere

_____

iv. a species which contributes to the enhanced greenhouse effect and to photochemical smog

_____

1 + 1 + 1 + 1 = 4 marks

b. The list below gives the names of several chemical reactions. Select a numeral (I to IV) from this list when answering the questions which follow.

I complete combustion of ethane

II photosynthesis in green plants

III the process of denitrification

IV thermal decomposition of calcium carbonate

Give the numeral or numerals (I to IV) from the list above for a reaction or reactions

i. in which oxygen gas is a reactant.

_____

ii. in which carbon dioxide gas is a **not** a product.

_____

iii. which produce an atmospheric gas (at SLC) other than oxygen or carbon dioxide.

_____

iv. in which oxidation and reduction do not occur.

_____

1 + 1 + 1 + 1 = 4 marks

Total 8 marks

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Question 3

a. An Australian company has developed a solar-powered desalination system consisting of flat, rectangular plastic-covered box units. Saltwater is fed into the top of the unit and runs down the solar plate in a thin film. Solar energy vaporises the water which then condenses on the inside surface of the plastic panel enclosure. The pure drinking water is collected at the bottom of the unit and piped into storage. The inventors of the solar distillation units claim that disease-causing microbes, ions and dissolved solids are removed from the water by their technique.

i. In this process the saltwater is not boiled and yet water evaporates.

Explain why some water evaporates at temperatures less than the boiling point of water.

_____

_____

_____

_____

_____

ii. Name one other desalination process which is used to produce fresh water.

_____

2 + 1 = 3 marks

b. In the usual treatment of drinking water, microbes are killed by adding chlorine gas during water treatment. The following reaction occurs.

$$Cl_2(g) + H_2O(l) \rightarrow HOCl(aq) + H^+(aq) + Cl^-(aq)$$

i. As chlorine gas is added to pure water, does the pH of the water increase, decrease or remain unchanged? Explain your choice.

_____

_____

_____

ii. Hypochlorous acid (HOCl) is a weak, monoprotic acid.

What is meant by the term ‘weak acid’?

_____

_____

iii. The reaction of chlorine and water shown above is a redox reaction.

Write a balanced half-equation for the reduction reaction.

_____

2 + 1 + 1 = 4 marks

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c. Rainwater washing over limestone deposits produces water often described as 'hard'. 'Hard' water does not lather easily with soap, making washing difficult, and it also causes deposits to form on the inside of water pipes. A Perth water sample has a hardness of 61 ppm (as $CaCO_3$).

i. Calculate the mass (in grams) of $CaCO_3$ which is present in 2.0×10^2 L of water in Perth.

Assume the density of the water is 1.0 g mL^{-1}.

_____

_____

_____

_____

ii. Calcium carbonate is insoluble in pure water but dissolves to an extent in rainwater.

Explain why this insoluble solid dissolves.

_____

_____

_____

iii. A common way of removing hardness from water is to dissolve sodium carbonate (Na_2CO_3) powder in it. This causes the calcium ions to form a precipitate which settles and thus 'softens' the water.

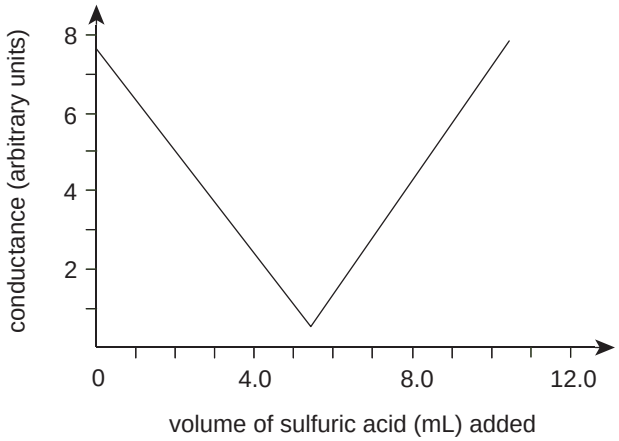
Write a balanced ionic equation for the precipitation reaction.

_____

2 + 1 + 1 = 4 marks
Total 11 marks

Question 4

An experiment was conducted to analyse the progress of a neutralisation reaction of barium hydroxide solution with sulfuric acid using electrical conductivity measurements. 20.0 mL of 0.050 M $Ba(OH)_2(aq)$ was placed into a beaker fitted with conductivity probes. Volumes of 1.0 mL of $H_2SO_4(aq)$ were added progressively to the beaker while stirring, and the conductivity of the beaker contents was measured. The results of the experiment are shown in the graph below.



a. State which piece of laboratory equipment could be used to measure the 1.0 mL volumes of sulfuric acid.

_____

1 mark

b. The barium hydroxide solution was made by dissolving a mass of solid barium hydroxide in water and then adding more water until the final volume was 100.0 mL.

i. Calculate the mass of barium hydroxide powder needed to make 100.0 mL of the 0.050 M solution.

_____

_____

ii. Explain why barium hydroxide conducts electricity when dissolved in water.

_____

_____

2 + 1 = 3 marks

c. Write a balanced equation for the reaction between the barium hydroxide and sulfuric acid solutions.

_____

2 marks

d. **i.** What volume of sulfuric acid was required to exactly neutralise the barium hydroxide solution?

_____

ii. Calculate the molarity of the sulfuric acid used in this experiment.

_____

_____

_____

1 + 3 = 4 marks

Total 10 marks

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Question 5

Nitrogen gas composes 78% of air at sea level. Nitrogen is used by all living organisms and is an important raw material in the industrial production of chemicals.

a. Nitrogen gas must be 'fixed' before it can be used by living things.

i. Explain the meaning of 'fixed' in this context.

_____

_____

_____

ii. Give an example of nitrogen being 'fixed' in a natural, non-biological process.

_____

_____

_____

1 + 1 = 2 marks

b. An important industrial use of nitrogen is the manufacture of nitric acid (HNO_3). Initially, nitrogen and hydrogen gases are reacted to form ammonia gas which is then oxidised to produce the acid in a series of steps.

i. In ammonia production, air is used as the source of nitrogen gas in the reaction vessel rather than pure nitrogen gas.

Suggest a reason for this.

_____

_____

ii. The final concentration of nitric acid from the process is 68% (m/v).

Calculate the pH of the acid at this concentration.

_____

_____

_____

_____

_____

iii. Concentrated nitric acid is a dangerous chemical. Any spills at the manufacturing plant are covered with sodium carbonate (Na_2CO_3) powder.

Write a balanced chemical equation for this reaction between nitric acid and sodium carbonate powder.

_____

1 + 3 + 2 = 6 marks

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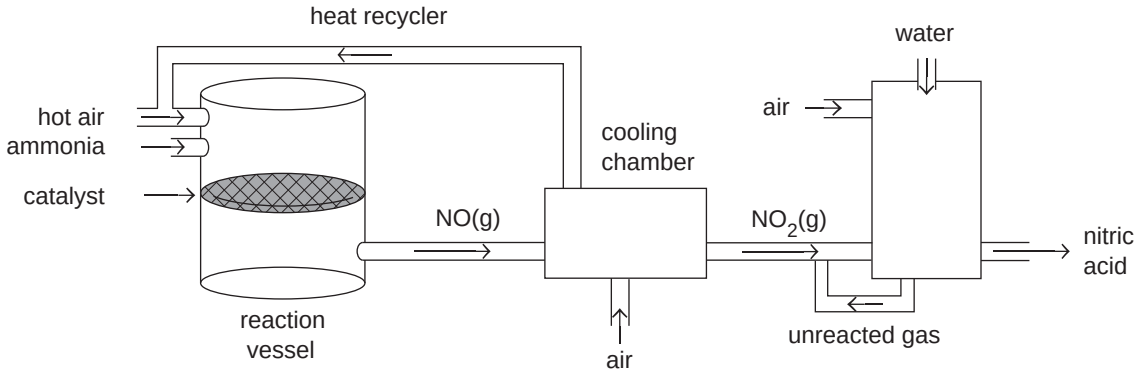
c. The principles of green chemistry are used extensively in the modern manufacture of nitric acid.

i. One of these principles is to maximise atom economy. The percentage atom economy indicates the sum of molar masses of the atoms in the desired product compared to the sum of molar masses of all the atoms in the reactants.

Calculate the percentage atom economy for the modern method which uses the chemical reaction shown below.

$$NH_3(g) + 2O_2(g) \rightarrow HNO_3(aq) + H_2O(l)$$

ii. This simplified diagram shows the important steps in the modern manufacture of nitric acid.



Identify **two** applications of green chemistry principles used in the manufacturing process shown in the diagram.

2 + 2 = 4 marks
Total 12 marks

END OF QUESTION AND ANSWER BOOKLET

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