Neap:

Trial Examination 2014

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 17 pages, with a detachable data book 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

The properties of water include:

I It has a specific heat capacity of 4.18 J g^{-1} °C^{-1}.

II The density of ice is lower than the density of liquid water.

III If water is heated to 2000°C, less than 1% of molecules decompose.

IV For 1 mole of liquid water at 100°C it takes 44 kilojoules of energy to cause a change of state.

Which one of the following options correctly shows the properties resulting primarily from intramolecular or intermolecular bonding?

	Type of bonding mainly responsible for properties	
	Intramolecular	**Intermolecular**
A.	I and II	III and IV
B.	III	I, II and IV
C.	III and IV	I and II
D.	IV	I, II and III

Question 2

Sulfuric acid (H_2SO_4) is a strong, diprotic acid. In a 1.0 M aqueous solution of H_2SO_4, three abundant chemical species in the solution, in order of increasing concentration, are

A. $SO_4^{2-} < HSO_4^{-} < H_2SO_4$

B. $HSO_4^{-} < H_2O < SO_4^{2-}$

C. $H_2SO_4 < SO_4^{2-} < H_3O^{+}$

D. $SO_4^{2-} < H_3O^{+} < H_2O$

Question 3

The density of nitrogen gas, in g L^{-1}, at STP is

A. 0.625

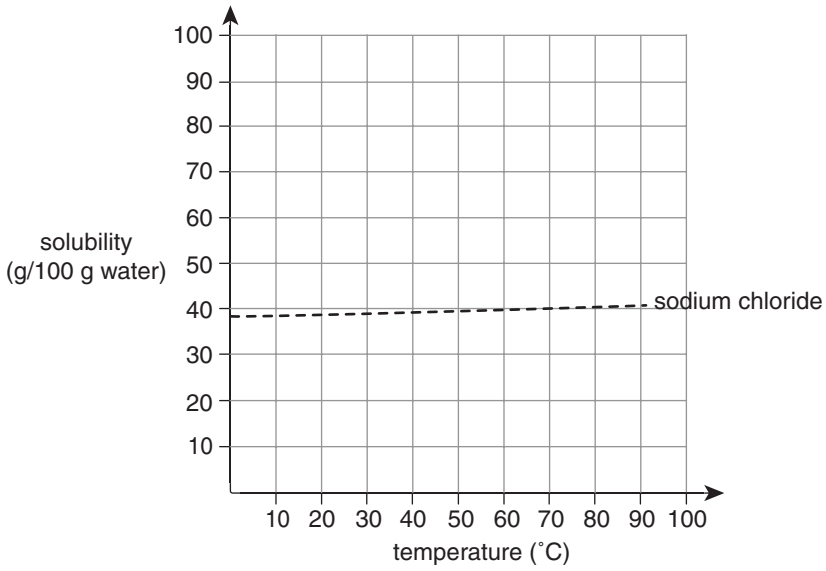
B. 0.800

C. 1.25

D. 1.60

Use the following information to answer Questions 4–6.

The solubility curve for sodium chloride is shown below.



Question 4

Which one of the following statements concerning sodium chloride is correct?

A. Adding some sodium chloride crystals to a saturated solution of sodium chloride at 50°C would produce an unsaturated solution.

B. Lowering the temperature of a saturated solution of sodium chloride from 80°C to 60°C would cause a significant mass of crystals to appear.

C. The ion concentration in a saturated sodium chloride solution at 40°C would show very little change if the solution was heated to 70°C, assuming no water evaporated from the solution.

D. The electrical conductivity of a solution of sodium chloride would be expected to remain constant as the solution is heated from 10°C to 90°C.

Question 5

The concentration of chloride ions in a saturated solution of sodium chloride at 60°C is closest to

A. 3.4 M

B. 6.8 M

C. 200 g L^{-1}

D. 400 g L^{-1}

Question 6

One process used to produce drinking water from saltwater is distillation.

In the process of distillation of saltwater

A. the saltwater is not heated above 60°C, as this would increase the solubility of sodium chloride.

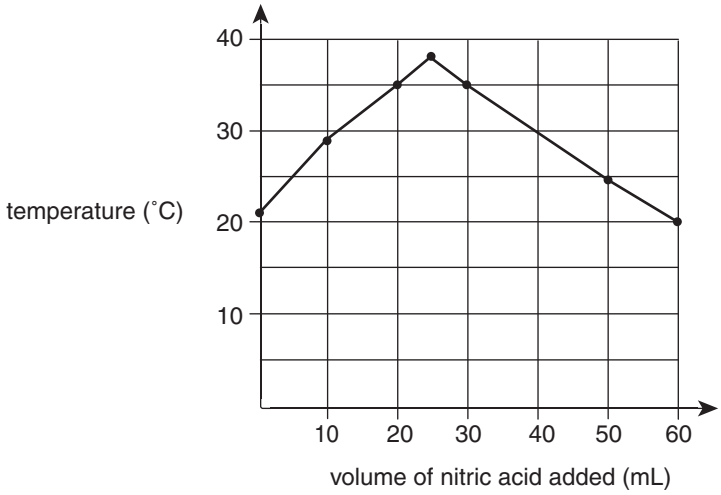
B. lowering the atmospheric pressure at which the distillation takes place is more energy efficient because it causes the solubility of the sodium chloride to increase.

C. the saltwater must be heated to 100°C before any pure water can be produced.

D. the concentration of sodium chloride in the saltwater being heated increases over time.

Use the following information to answer Questions 7 and 8.

The chemical reaction between sodium hydroxide solution and nitric acid produces heat. In an experiment, 20.0 mL of dilute sodium hydroxide solution was dispensed into an insulated beaker and 10.0 mL of dilute nitric acid was added with stirring. The highest temperature reached was recorded. The original experiment was repeated a number of times using different volumes of dilute nitric acid and the results were plotted, as shown below.



Question 7

The chemical reaction in the experiment is best described as being between a

A. strong acid and a strong base.
B. strong acid and a weak base.
C. weak acid and a weak base.
D. weak acid and a strong base.

Question 8

If the concentration of the sodium hydroxide solution used was 0.80 M, the concentration (in M) of the nitric acid used in the experiment is closest to

A. 0.53
B. 0.64
C. 0.80
D. 1.0

Question 9

X has the following properties:

- X is a molecular ion.
- X reacts with sodium hydroxide to produce a salt and water.
- X reacts with sulfuric acid to produce a salt, water and carbon dioxide.

Based on the information provided, it can be concluded that X is

A. an acid only
B. a base only
C. amphiprotic
D. neither an acid nor a base

Use the following information to answer Questions 10–12.

At 25°C, iron nails were placed in solutions of different pH, with all other conditions being kept constant. After a set time the percentage corrosion of each nail was calculated. Results are shown in the table below.

pH of solution	1	2	3	4	5	6	7
corrosion (%)	60	55	50	45	15	10	5

The overall reaction for the corrosion process is shown by the following equation:

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

Question 10

The concentration of the hydroxide ion in the solution of pH 4 is

A. zero, as it is an acidic solution and so there are only hydrogen ions present.

B. 10^{-10} M

C. 10^{-4} M

D. 10 M

Question 11

Which of the following correctly identifies the oxidant and reductant in the corrosion process shown in the given equation?

	oxidant	**reductant**
A.	H_2O	H_2O
B.	H_2O	Fe
C.	O_2	H_2O
D.	O_2	Fe

Question 12

From the information provided, it can be concluded that

A. there would be less corrosion if dissolved oxygen was removed from the solutions.

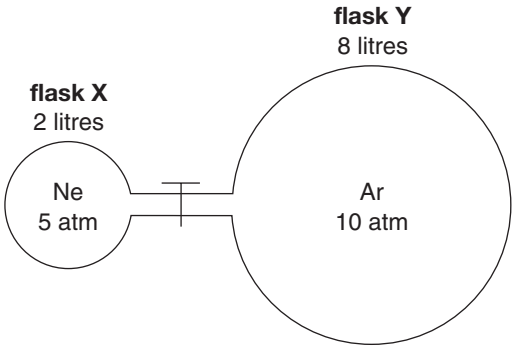
B. the lower the hydrogen ion concentration, the greater the extent of corrosion.

C. corrosion will not occur if the experiment is conducted at a pH of 8 and a temperature of 50°C.

D. halving the acidity of a solution of pH 6 increases corrosion by a factor of 5.

Use the following information to answer Questions 13 and 14.

At constant temperature, samples of neon and argon gases at different pressures were placed into separate flasks connected by a tap which is closed.



Question 13

Consider the following statements in regards to the flasks:

I Flask Y contains more gas particles than flask X.

II All gas particles in both flasks travel at the same speed.

III The average kinetic energy of the gas particles in flasks X and Y is the same.

Which of the above statements are correct?

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

Question 14

The tap is opened with the temperature remaining unchanged.

Which of the following shows the gas pressure of neon and the total gas pressure when the tap has been opened and the gases allowed to mix?

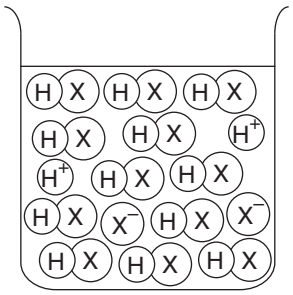
	Gas pressure of Ne (atm)	**Total gas pressure (atm)**
A.	1	9
B.	1	15
C.	2	9
D.	2	15

Question 15

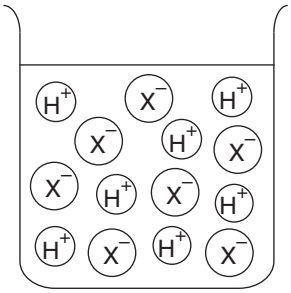
The diagrams below represent particles present in acid solutions.

Which of the diagrams best represents a concentrated solution of a weak acid?

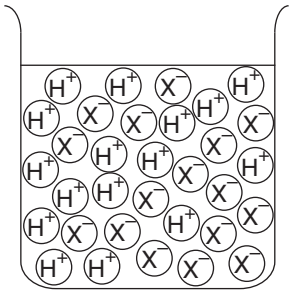
A.



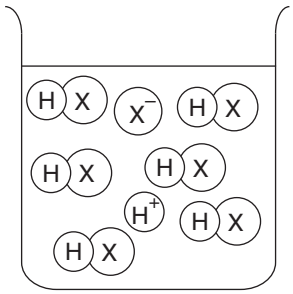
B.



C.



D.



Question 16

A common method of protection against corrosion in items made of iron is to coat them with a more reactive metal. An example of this is galvanising, which involves dipping the item in molten zinc. A student made the following conclusions from this information:

I Zinc provides a physical barrier preventing water and air from being in contact with the iron surface.

II If the zinc coating is scratched, exposing the iron surface, the iron will corrode immediately.

III Zinc is likely to react with oxygen in the air to produce zinc oxide.

Which of the above conclusions are correct?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Question 17

The ionic equation below shows the reaction between dichromate ions and iodide ions in an acidic solution:

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6I^-(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(l) + 3I_2(aq)$$

The amount (in mol) of iodine that would be produced as a result of the reaction between 0.035 mol of $Cr_2O_7^{2-}$ ions and 0.19 mol of I^- ions would be

A. 0.095

B. 0.11

C. 0.38

D. 0.57

Question 18

A particular chemical process includes the following features:

I treating toxic by-products to make them harmless

II the use of gases extracted from crude oil

III involvement of catalysts in several reactions

IV recycling waste heat within the process

Which of the above are applications of the principles of green chemistry?

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

Question 19

Some effects of environmental problems include:

I increased incidence of skin cancer

II deterioration of plastics

III reduction in plant growth

IV potential flooding of low-lying countries

Which of the problems above may be caused by depletion of the ozone layer?

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

Question 20

Methane gas is a potent cause of the enhanced greenhouse effect.

What is the main source of methane gas in the atmosphere?

A. transport vehicles
B. refining of crude oil
C. rubbish dumps
D. agriculture

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 (12 marks)

A range of man-made fertilisers are manufactured for agricultural use to improve plant growth and crop yields. Ammonia (NH_3) plays a pivotal role in fertiliser production. It has a boiling point of –33°C and is highly soluble in water. Ammonia is a toxic gas which is extremely irritating to eyes and the respiratory system.

a. Ammonia is manufactured industrially in large quantities using the chemical reaction represented by the following equation:

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

i. The hydrogen gas is often obtained from methane.

What is the likely source of nitrogen gas? 1 mark

_____

ii. What is the maximum volume of ammonia (in L) at 20°C and 100 000 Pa which could be produced from 150 kg of hydrogen, assuming complete reaction occurs? 4 marks

_____

_____

_____

_____

b. Ammonia can be transported from the manufacturer and injected directly into the soil as a fertiliser.

i. Suggest one disadvantage of transporting the ammonia to a farm. 1 mark

_____

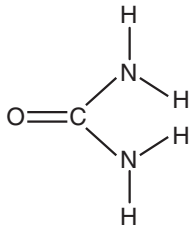
_____

ii. Suggest a problem which may occur if the ammonia is injected directly into the soil as a fertiliser. 1 mark

_____

_____

c. Many of the problems associated with the use of ammonia can be overcome by using urea, a fertiliser manufactured from ammonia. The molecular structure of urea is shown below.



i. Explain why urea is highly soluble in water and, on the diagram above, draw several water molecules to show the interactions of water with the urea molecule. Label both bond types present (other than dispersion forces). 3 marks

_____

_____

_____

_____

ii. Calculate the percentage by mass of nitrogen in urea. 1 mark

_____

_____

iii. In damp soil, each molecule of urea is broken down to produce two molecules of ammonia.

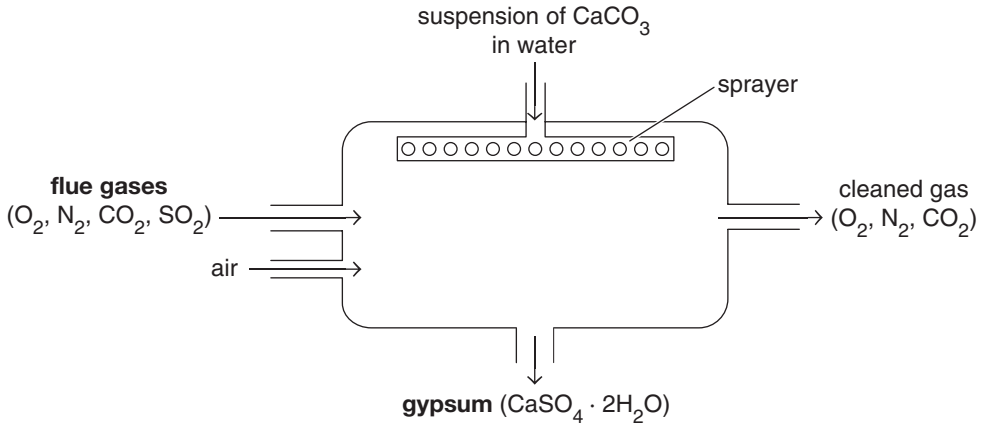
What is the likely effect of using urea on the pH of the soil? 1 mark

_____

_____

Question 2 (11 marks)

Some types of coal contain large amounts of sulfur. When the coal is burnt in power stations, sulfur dioxide is released in the **flue gases**. To minimise this problem the gases can be treated by the process of **flue gas desulfurisation (FGD)**, as shown in the simplified diagram below.



a. Explain why releasing sulfur dioxide gas into the atmosphere can damage the environment. Include a balanced chemical equation in your explanation. 2 marks

_____

_____

_____

_____

b. The reactions which occur in the FGD chamber are represented by the following equations:

I $CaCO_3(s) + SO_2(g) \rightarrow CaSO_3(s) + CO_2(g)$

II $2CaSO_3(s) + O_2(g) + 2H_2O(l) \rightarrow 2CaSO_4.2H_2O(s)$

Calculate the mass of gypsum ($CaSO_4.2H_2O$) produced for each tonne (10^6 g) of limestone ($CaCO_3$) used in FGD. 3 marks

_____

_____

_____

_____

c. Both carbon dioxide and calcium carbonate play a role in the carbon cycle.

i. From the carbon cycle, outline a natural process involved in each action shown in the table below. 2 marks

Removing carbon dioxide gas from the atmosphere	
Releasing carbon dioxide gas into the atmosphere	

ii. Calcium carbonate is almost insoluble in pure water but dissolves in rainwater according to the following equation:

$$H_2O(l) + CO_2(g) + CaCO_3(s) \rightarrow Ca(HCO_3)_2(aq)$$

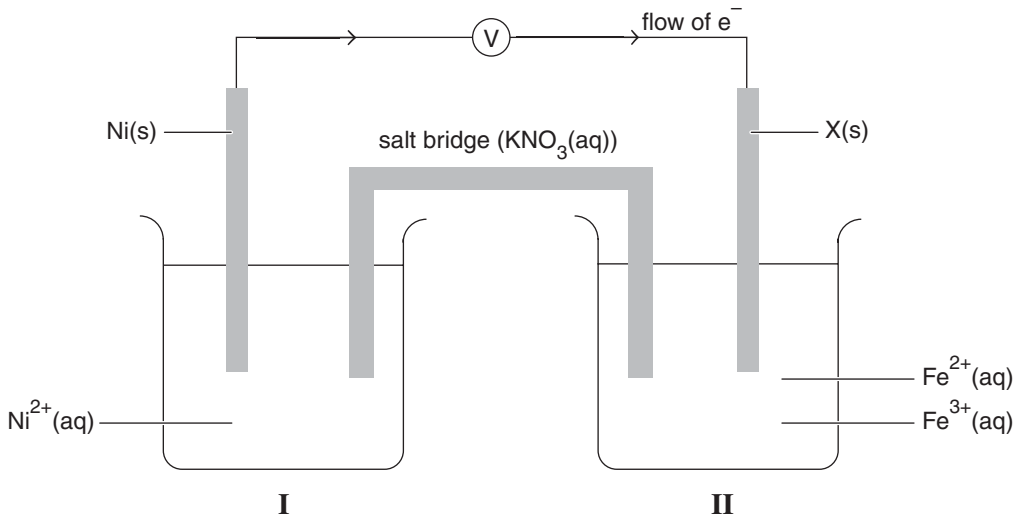
When rainwater is collected after it has run over exposed calcium carbonate deposits the water is described as 'hard'.

From the procedures listed in the table below, identify **one** method which **will** remove the 'hardness' of a sample of 'hard' water, and identify **one** method which **will not** remove the 'hardness' of a sample of 'hard' water. Explain your two choices.
(You are required to complete only two rows of the table.) 4 marks

Procedures	**Will the procedure remove the 'hardness' of the water? (Write YES or NO)**	**Explanation**
Distillation		
Filtration using ordinary filter paper		
Reverse osmosis		
Boiling		

Question 3 (9 marks)

A galvanic cell is constructed by combining two half-cells as shown in the diagram below. The solution in half-cell I is prepared by dissolving 4.75 g of nickel nitrate ($Ni(NO_3)_2$) salt in 250.0 mL of water. The solution in half-cell II was prepared using iron nitrate salts, and contains 0.025 mol each of iron(II) and iron(III) ions in a volume of 250.0 mL. When the cell is operating the electron flow is as shown.



a. **i.** Write a balanced ionic equation for the reaction occurring in the cell. 1 mark

_____

ii. Give the symbol for the species acting as the oxidant when the cell is operating. 1 mark

_____

iii. Which electrode (Ni or X) is the anode? 1 mark

_____

iv. Which electrode (Ni or X) carries a positive charge? 1 mark

_____

v. Give the chemical symbol for a substance that would be suitable for use as electrode X in this cell. 1 mark

_____

b. **i.** Calculate the concentration of nitrate ions in half-cell I before the half-cells are connected and the current begins to flow. 3 marks

_____

_____

_____

ii. How would the concentration of nitrate ions in half-cell I be expected to change as the galvanic cell operates? Indicate your answer using one of the words *increase*, *decrease* or *remain unchanged*. 1 mark

_____

Question 4 (15 marks)

The atmosphere is composed of a number of different gases.

a. Methods for the laboratory preparation of some of the gases present in the atmosphere are shown in the table below.

Identify how **one** gas is prepared by writing its name in the appropriate space next to its preparation method. 1 mark

Method of preparation	Name of gas
A solution of ammonium nitrate is boiled vigorously.	
Manganese(IV) oxide is added to hydrogen peroxide solution.	
Cold 50% nitric acid is used to reduce copper metal.	
Solid calcium carbonate is reacted with hydrochloric acid.	
Copper metal is reacted with concentrated nitric acid.	

b. The solubilities of various gases at atmospheric pressure in water at different temperatures are shown in the table below.

Solute	Solubility (g of solute in 100 g water)			
	0°C	**20°C**	**40°C**	**60°C**
nitrogen	0.0029	0.0019	0.0015	0.0011
oxygen	0.0069	0.0043	0.0030	0.0023
carbon dioxide	0.34	0.17	0.091	0.058
methane	0.0040	0.0023	0.0017	0.0011

i. Calculate the volume of oxygen gas, in mL, which will dissolve in 100 g of water at STP. 2 marks

_____

_____

_____

ii. How many molecules of methane gas will dissolve in 450 g of water at 60°C? 3 marks

_____

_____

_____

_____

iii. Potassium nitrate (KNO_3) is also soluble in water.

Give one significant difference which is likely to be evident if the data for the solubility of potassium nitrate was included in the table of solubilities above. 1 mark

_____

_____

iv. Most molecular substances will not conduct electricity when dissolved in water. An exception is hydrogen chloride.

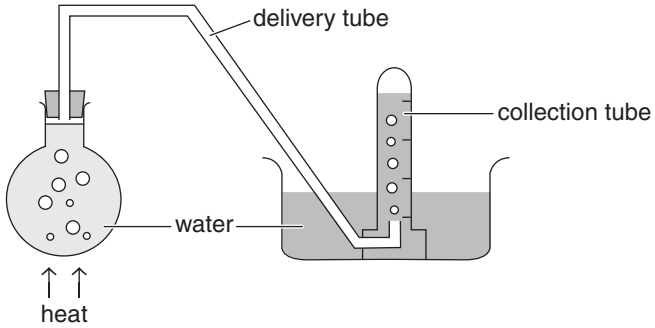
With the aid of an equation, explain why an aqueous solution of HCl will conduct electricity. 2 marks

_____

_____

_____

c. To collect 50 mL of the air dissolved in water, a flask full of water was boiled using the experimental set-up shown in the diagram below. The inverted collection tube was put in place after the water in the flask had been boiling for a few minutes.



50 mL of dissolved air sample was collected. This 50 mL gas sample was repeatedly passed over gently heated magnesium powder until no further change in volume was evident. The magnesium reacted with the dissolved air sample to produce magnesium oxide.

i. Write a balanced equation for the reaction between the magnesium and the air sample. 1 mark

_____

ii. Write the reduction half-equation for the reaction which occurred between the magnesium and the air sample. *(States are not required.)* 1 mark

_____

iii. After the dissolved air sample had reacted with the magnesium, the volume of the remaining gaseous sample was 34 mL.

Calculate the percentage of oxygen in the 50 mL of dissolved air sample. 2 marks

_____

_____

iv. Approximately 20% of the air in the atmosphere is oxygen gas.

Explain the difference between this value and the value calculated in part **iii** for percentage of oxygen in the dissolved air sample. 2 marks

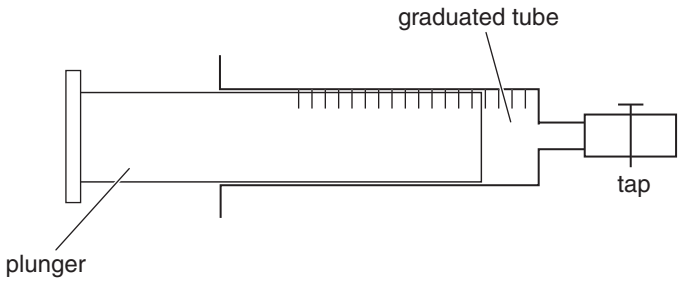
_____

_____

_____

Question 5 (8 marks)

A gas syringe consists of a graduated glass tube with a closely-fitting plunger which slides easily. A tap can be attached to seal any gas in the syringe. A simplified diagram of a gas syringe is shown below.



a. The brown gas nitrogen dioxide (NO_2) is formed as the only product when nitrogen monoxide gas reacts with oxygen gas.

Write an equation for the formation of nitrogen dioxide from nitrogen monoxide. 1 mark

_____

b. 40 mL of nitrogen dioxide gas at 20°C and atmospheric pressure was placed in a gas syringe and the tap was closed. The temperature was increased to 40°C at atmospheric pressure. The volume of gas in the syringe increased as the plunger moved outwards.

i. Explain the movement of the plunger using the kinetic molecular theory of gases. 2 marks

_____

_____

_____

_____

ii. Calculate the final volume of the gas at 40°C. 2 marks

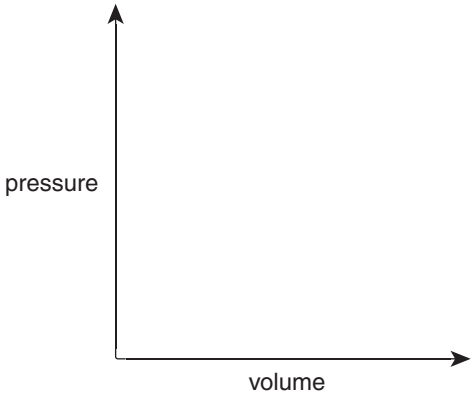
_____

_____

_____

iii. The temperature was returned to 20°C at atmospheric pressure. The plunger was then pushed slowly, and the volume measured at regular intervals.

Sketch the graph of the expected results of this experiment using the axes below. 1 mark



c. Nitrogen dioxide is a component of photochemical smog.

i. Identify one other reactant or condition which is needed for the production of photochemical smog. 1 mark

_____

ii. Describe one detrimental effect of photochemical smog. 1 mark

_____

END OF QUESTION AND ANSWER BOOKLET