VCE CHEMISTRY 2009

YEAR 11 TRIAL EXAM UNIT 2

Time allowed: 90 Minutes
Total marks: 75

Section A
Contains 24 Multiple Choice Questions
24 marks, 27 minutes

Section B
Contains 6 Short Answer Questions
51 marks, 63 minutes

To download the Chemistry Data Book please visit the VCAA website:
http://www.vcaa.vic.edu.au/vce/studies/chemistry/chem1_sample_2008.pdf *Page 20*

Learning Materials *by Lisachem*
PO Box 2018, Hampton East, Victoria, 3188
Ph: (03) 9598 4564 Fax: (03) 8677 1725
Email: orders@learningmaterials.com.au or orders@lisachem.com.au
Website: www.learningmaterials.com.au

Student Name...

VCE Chemistry 2009 Year 11 Trial Exam Unit 2

Student Answer Sheet

Instructions for completing test. Use only a 2B pencil. If you make a mistake erase and enter the correct answer. Marks will not be deducted for incorrect answers.

Write your answers to the Short Answer Section in the space provided directly below the question. There are 24 Multiple Choice questions to be answered by circling the correct letter in the table below.

Question 1	A	B	C	D	*Question 2*	A	B	C	D
Question 3	A	B	C	D	*Question 4*	A	B	C	D
Question 5	A	B	C	D	*Question 6*	A	B	C	D
Question 7	A	B	C	D	*Question 8*	A	B	C	D
Question 9	A	B	C	D	*Question 10*	A	B	C	D
Question 11	A	B	C	D	*Question 12*	A	B	C	D
Question 13	A	B	C	D	*Question 14*	A	B	C	D
Question 15	A	B	C	D	*Question 16*	A	B	C	D
Question 17	A	B	C	D	*Question 18*	A	B	C	D
Question 19	A	B	C	D	*Question 20*	A	B	C	D
Question 21	A	B	C	D	*Question 22*	A	B	C	D
Question 23	A	B	C	D	*Question 24*	A	B	C	D

VCE Chemistry 2009 Year 11 Trial Exam Unit 2

Multiple Choice Questions - Section A

(24 marks, 27 minutes)

This section contains 24 multiple choice questions.
For each question choose the response that is correct or best answers the question.
Indicate your answer on the answer sheet provided.
*(Choose only **one** answer for each question.)*

Question 1
A solution was prepared by mixing 50.0 mL of an aqueous 0.100 M sodium chloride solution with 50.0 mL of an aqueous 0.200 M calcium chloride solution. The chloride ion concentration in the resulting solution would be
A. 0.200 M.
B. 0.150 M.
C. 0.250 M.
D. 0.300 M.

Question 2
Which one of the following gases would not directly contribute to the formation of acid rain?
A. Sulfur dioxide, SO_2.
B. Nitrogen(IV) oxide, NO_2.
C. Carbon dioxide, CO_2.
D. Ozone, O_3.

Question 3
In a redox reaction electrons are transferred from
A. the reductant to the oxidant which is oxidised in the process.
B. the reductant to the oxidant which is reduced in the process.
C. the oxidant to the reductant which is reduced in the process.
D. the oxidant to the reductant which is oxidised in the process.

Question 4
A base is **best** described as a substance that
A. can donate a hydroxide ion.
B. leads to the formation of hydroxide ions in water.
C. changes the colour of methyl red to yellow.
D. can accept protons.

Question 5

The reaction that occurs when magnesium carbonate is heated can be described by the chemical equation

$$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$$

When a sample of pure magnesium carbonate was heated, the volume of carbon dioxide formed at SLC was 1.365 L. The mass of magnesium oxide that would be formed from this sample would be

A. 4.697 g.
B. 2.245 g.
C. 1.250 g.
D. 2.456 g.

Question 6

The conjugate acid for the monohydrogen phosphate ion, HPO_4^{2-}, in aqueous solution is

A. $H_2PO_4^-$(aq).
B. PO_4^{3-}(aq).
C. H_3O^+(aq)
D. $H_2PO_4^{3-}$(aq)

Question 7

Global warming has been linked to the greenhouse effect, resulting from increased levels of carbon dioxide and other gases in the atmosphere, which

A. inhibits the reflection of ultraviolet radiation back into space.
B. allows more infrared radiation to pass through the atmosphere from space.
C. allows more ultraviolet radiation to pass through the atmosphere from space.
D. inhibits the reflection of infrared radiation back into space.

Question 8

20.0 mL of 0.100 M aqueous sodium hydroxide was diluted with deionised water so that the total volume was 2.00 L. The pH of the diluted solution would be closest to

A. 11
B. 13
C. 1
D. 3

Question 9
In Green chemistry the concept of atom economy involves
A. using synthetic pathways that incorporate a maximum proportion of the atoms of the reactants in the product.
B. minimising the energy required for a synthetic pathway so that it is more economical.
C. using catalysts that produce only the desired products and prevent the formation of other by-products that can be formed in synthetic pathways.
D. producing a product that has either the capability of being biodegradable or recycled when it reaches the end of its useful life span.

Question 10
The products formed when an aqueous solution of nitric acid reacts with a stoichiometric amount of sodium hydrogen carbonate to form a neutral solution would be
A. $NaNO_3(aq)$ and $CO_2(g)$.
B. $NaNO_3(s)$, $CO_2(g)$ and $H_2O(l)$.
C. $NaNO_3(s)$ and $H_2O(l)$.
D. $NaNO_3(aq)$, $CO_2(g)$ and $H_2O(l)$.

Question 11
Oxygen gas is prepared on the industrial scale by
A. the electrolysis of water.
B. reacting hydrogen peroxide with potassium permanganate.
C. the fractional distillation of liquid air.
D. heating a mixture of potassium chlorate and manganese(IV) oxide.

Question 12
Which one of the following statements best describes why an aqueous solution of copper(II) sulfate will weakly conduct an electric current?
A. The copper(II) sulfate causes the water to ionise and these ions carry the electric current.
B. The copper(II) sulfate dissociates in water and the ions formed carry the electric current.
C. Copper(II) sulfate is an acid and when dissolved in water it forms H_3O^+ ions that carry the electric current.
D. The copper(II) sulfate releases electrons into the solution and these carry the current.

Question 13

Nitrate ions play a significant role in the nitrogen-oxygen cycle. Which one of the following does not form part of this cycle?

A. The action of bacteria in the soil that convert ammonium ions to nitrate ions.

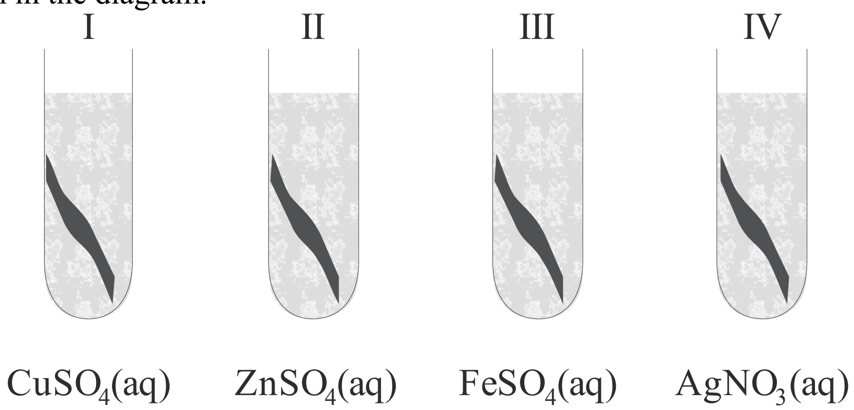
B. The formation of nitrate ions from various nitrogen oxides in the atmosphere.

C. The oxidation of nitrogen by bacteria in the root nodules of some plants to form nitrate ions.

D. The industrial production of nitrate based fertilisers involving the oxidation of ammonia.

Question 14

A strip of nickel is added into four test tubes containing aqueous solutions of different metal salts as shown in the diagram.



In which test tubes will a reaction occur?

A. Test tubes I and III only.

B. Test tubes II and III only.

C. Test tubes II and IV only.

D. Test tubes I and IV only.

Question 15

The reaction between zinc metal and lead(II) ions in an aqueous solution can be represented by the chemical equation

$$Zn(s) + Pb^{2+}(aq) \rightarrow Zn^{2+}(aq) + Pb(s)$$

The mass of lead that would be formed when 3.01 g of zinc metal is placed in a solution containing 0.048 mol of lead(II) ions would be

A. 3.01 g.

B. 9.5 g.

C. 9.9 g.

D. 3.1 g.

Question 16
In aqueous solutions the hydrogen selenate ion, $HSeO_4^-(aq)$, can display
A. basic properties.
B. acidic properties.
C. amphiprotic properties.
D. polyprotic properties.

Question 17
The complete combustion of propane can be represented by the chemical equation

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

The volume of oxygen required to produce 3.6 L of carbon dioxide at the same temperature and pressure is
A. 1.2 L.
B. 6.0 L.
C. 3.6 L.
D. 4.8 L.

Question 18
18.27 g of a gas occupied a volume of 14.9 L at SLC. The gas would most likely be
A. ethane, C_2H_6.
B. propane, C_3H_8.
C. ammonia, NH_3.
D. hydrogen cyanide, HCN.

Question 19
The amount of sodium carbonate required to neutralise 0.50 mol of a diprotic acid would be
A. 0.25 mol.
B. 0.50 mol.
C. 1.0 mol.
D. 0.75 mol.

Question 20
Coating steel with zinc metal is an example of
A. passive corrosion protection.
B. anodic corrosion protection.
C. sacrificial corrosion protection.
D. cathodic corrosion protection.

Question 21
The reaction between aqueous solutions of barium hydroxide and hydrochloric acid can be represented by the chemical equation

$$Ba(OH)_2(aq) + 2HCl(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$$

26.53 mL of an aqueous hydrochloric acid solution is required to neutralise a 10.00 mL sample of a 0.126 M aqueous barium hydroxide solution. The concentration of the hydrochloric acid solution is
A. 0.0475 M.
B. 0.0950 M.
C. 0.190 M.
D. 0.167 M.

Question 22
In an aqueous solution of a strong acid
A. there is a high concentration of the $H_3O^+(aq)$ ion.
B. there is a high concentration of the acid.
C. the majority of the acid is unionised.
D. the majority of the acid is ionised.

Question 23
Which one of the following materials does **not** play a role in the formation of photochemical smog?
A. Unburnt hydrocarbon gases.
B. Oxygen.
C. Carbon dioxide.
D. Nitrogen oxides.

Question 24
The Kyoto protocol is an international agreement that targets reductions in the
A. proliferation of radioactive materials.
B. emission of greenhouse gases.
C. consumption of fossil fuels.
D. emission of ozone depleting agents.

End of Section A

VCE Chemistry 2009 Year 11 Trial Exam Unit 2

Short Answer Questions - Section B

(51 marks, 63 minutes)

This section contains six questions, numbered 1 to 6.
All questions should be answered in the spaces provided.
The mark allocation and approximate time that should be spent on each question are given.

Question 1 (8 marks, 10 minutes)
Lithium metal will react with oxygen and moisture in the air during storage, so that most samples contain a mixture of the metal and its oxide, Li_2O.

a. The reaction that occurs when lithium reacts with water can be represented by the chemical equation

$$2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$$

i. What type of chemical reaction occurs when lithium metal reacts with water?

ii. What role does water play in this reaction?

(1 + 1 = 2 marks)

b. When solid lithium oxide reacts with water it produces an aqueous solution of lithium hydroxide.

i. Write an appropriate chemical equation to describe this reaction.

ii. What role does water play in this reaction?

(1 + 1 = 2 marks)

c. When a 1.225 g sample containing lithium metal and lithium oxide was allowed to react with water, the volume of hydrogen gas produced at 107.5 kPa and 18.3 ºC was 1.247 L.

i. Calculate the amount in mol of hydrogen gas formed in this reaction.

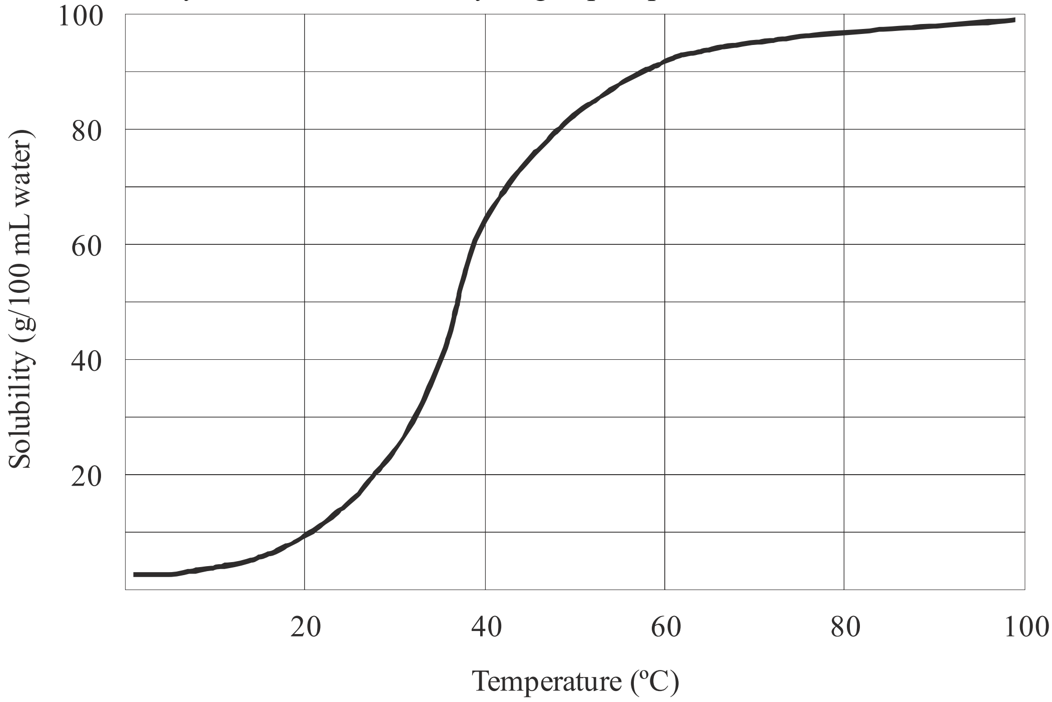
ii. Calculate the mass of lithium metal in the sample.

iii. Calculate the percentage by mass of lithium oxide in the sample.

(1 + 1 + 2 = 4 marks)

Question 2 (9 marks, 11 minutes)

a. The solubility curve for disodium hydrogen phosphate, Na_2HPO_4, is shown below.



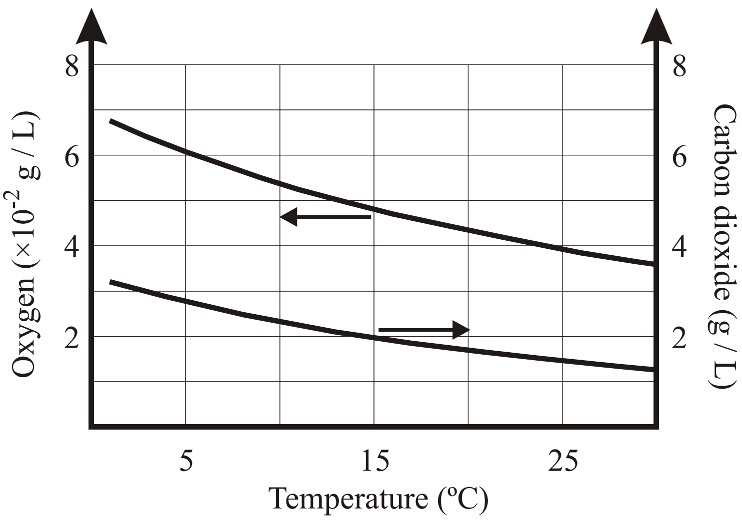
i. What is the minimum mass of disodium hydrogen phosphate that would need to be dissolved in 250.0 mL of deionised water to prepare a saturated solution at 40 ºC?

ii. What is the molar concentration of the hydrogen phosphate ion in this solution?

iii. A group of students prepared a saturated solution of disodium hydrogen phosphate by adding excess solid to deionised water at 70 ºC. They then took 50.0 mL of the solution and cooled it to 25 ºC. What mass of disodium hydrogen phosphate would the students expect to collect when they filtered the sample?

(1 + 2 + 2 = 5 marks)

b. The solubility curves for oxygen and carbon dioxide at normal atmospheric pressure are shown below. Carbon dioxide is significantly more soluble in water than oxygen.



i. What effect does increasing the temperature have on the amount of gases available to aquatic animals and plants?

ii. Explain how quality of aquatic life in a pond can change over a prolonged period of hot weather.

iii. A student had a number gold fish in a small aquarium and continually aerated the water using an air pump. Why is it necessary to continue the aeration of the water?

iv. The oceans are a vast sink for carbon dioxide in the environment. What effect will increasing temperatures have on the amounts of carbon dioxide that can be absorbed from the atmosphere?

(1 + 1 + 1 + 1 = 4 marks)

Question 3 (8 marks, 10 minutes)

a. The ozone layer in the upper atmosphere shields the Earth's surface from some of the ultraviolet radiation that is emitted by the Sun. A depletion of the ozone layer was first recognised in the early 1970s and continued depletion has been recorded since.

i. What is one group of mainly industrially produced chemicals that have been associated with ozone depletion?

ii. What is one property of this group of chemicals that made them popular for use in society?

iii. What is one consequence that a reduction in the amount of ozone in the upper atmosphere has had on society?

iv. What is one step that has been taken in an attempt to reduce or reverse the depletion of ozone in the upper atmosphere?

(1 + 1 + 1 + 1 = 4 marks)

b. The gases in the atmosphere play a dynamic role in the carbon-oxygen cycle.

i. What are two chemical reaction processes that have significant impacts on the carbon-oxygen cycle?

ii. Select one of the processes mentioned in i. above, and with reference to the carbon-oxygen cycle explain what the process involves.

iii. How have the actions of society over the past 200 years had a more significant impact on the carbon-oxygen cycle compared with that for the previous 2000 years?

(2 + 1 + 1 = 4 marks)

Question 4 (9 marks, 11 minutes)

a. Sulfurous acid, H_2SO_3, is a weak diprotic acid in aqueous solutions.

i. Write two appropriate chemical equations to show the ionisation of sulfurous acid in water.

ii. Which sulfur containing species would have the highest concentration in a 0.1 M aqueous sulfurous acid solution?

(2 + 1 = 3 marks)

b. Write an appropriate chemical equation to show the reaction that would occur between solid magnesium oxide and an aqueous solution of ethanoic acid.

(1 mark)

c. 500.0 mL of an aqueous 0.10 M hydrochloric acid solution is added to 500.0 mL of an aqueous 0.050 M sodium hydroxide solution. Calculate the pH of the resultant solution.

(2 marks)

d. A group of students was given the task of analysing a solid mixture containing calcium hydroxide and sodium chloride. The reaction of calcium hydroxide with hydrochloric acid can be represented by the chemical equation

$$Ca(OH)_2(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

The students found that 25.60 mL of an aqueous 0.249 M hydrochloric acid solution was required to neutralise the calcium hydroxide in a 0.381 g sample of the mixture.

i. Calculate the amount of acid required to neutralise the calcium hydroxide.

ii. Calculate the mass of calcium hydroxide in the sample.

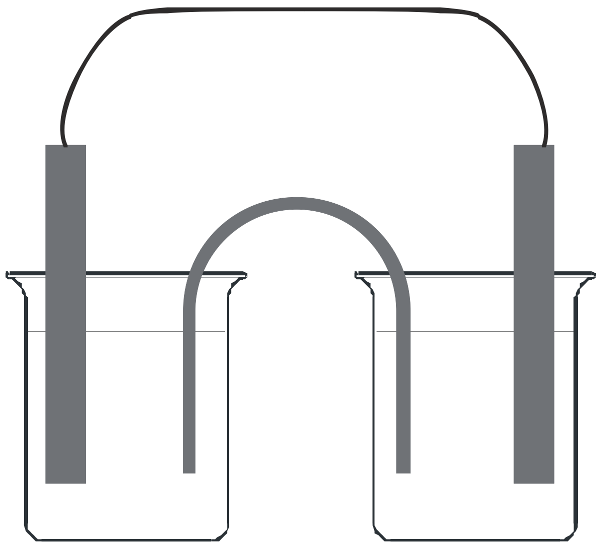
iii. Calculate the percentage by mass of calcium hydroxide in the sample.

(1 + 1 + 1 = 3 marks)

Question 5 (9 marks, 11 minutes)

a. A galvanic cell was constructed by combining the $Ag^{+}(aq)/Ag(s)$ and $Co^{2+}(aq)/Co(s)$ half-cells. On the diagram below indicate:

i. the constituents of the two half-cells,
ii. the polarity of the electrodes,
iii. the anode and cathode,
iv. the direction of electron flow,
v. the direction of ion flow, and
vi. a suitable electrolyte for use in the salt bridge.



(6 × 1 = 6 marks)

b. Write an appropriate chemical equation for the reaction that occurs in the galvanic cell in a.

(1 mark)

c. In wet corrosion of steel, what are two factors that can lead to an increased rate of corrosion?

(2 marks)

Question 6 (8 marks, 10 minutes)

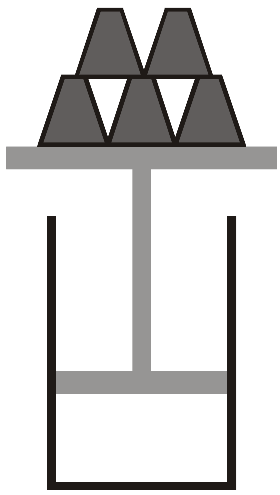
a. Use the kinetic molecular theory to explain the following observations about the behaviour of a gas in a container with a fixed volume.

i. The pressure of gas samples at the same temperature is directly proportional to the amount of gas present in the container.

ii. When the temperature of a gas sample is lowered, the pressure of the gas inside the container decreases.

(1 + 1 = 2 marks)

b. A sample of a gas in a piston, as shown in the diagram, has a volume of 0.50 L when five heavy blocks are placed on top of the piston. What would be the volume of the same gas sample if two of the blocks were removed? Assume that the mass of the piston is negligible compared to the mass of one of the heavy blocks.



(1 mark)

c. The total pressure of a 56.0 L sample of moist hydrogen at 20.0 ºC is 106.3 kPa. The partial pressure of water vapour at this temperature is 2.30 kPa. What volume of dry hydrogen would be present at SLC?

(2 marks)

d. A sealed 5.0 L vessel contains a stoichiometric mixture of methane and oxygen gases at SLC. The mixture is ignited using a spark plug and the gas mixture is returned to its original temperature.

i. Write an appropriate chemical equation for the complete combustion of methane at SLC.

ii. What would be the pressure inside the vessel after the reaction?

(1 + 2 = 3 marks)

End of Section B

End of Trial Exam

Suggested Answers

VCE Chemistry 2009 Year 11 Trial Exam Unit 2

Multiple Choice Answers - Section A

(1 mark per question)

Q1 **C** n(NaCl) = c × V = 0.100 × (50.0/1000) = 5.00×10^{-3} mol
n($CaCl_2$) = c × V = 0.200 × (50.0/1000) = 1.00×10^{-2} mol
n(Cl^-) = n(NaCl) + 2×n($CaCl_2$)
n(Cl^-) = $5.00\times10^{-3} + 2\times1.00\times10^{-2} = 2.50\times10^{-2}$ mol
V = 50.0 + 50.0 = 100.0 mL
c(Cl^-) = n / V = 2.50×10^{-2} / (100.0/1000) = **0.250 M**

Q2 **D** Ozone is the only gas that is not an acidic oxide, therefore it would not contribute directly to the formation of acid rain.
SO_2 leads to the formation of sulfurous acid and can be oxidised by oxygen or ozone to form sulfur trioxide, SO_3, which can form sulfuric acid.
$SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$
Nitrogen(IV) oxide will form nitric and nitrous acids.
$2NO_2(g) + H_2O(l) \rightarrow HNO_3(aq) + HNO_2(aq)$
Carbon dioxide will form carbonic acid.
$CO_2(g) + H_2O(l) \rightarrow H_2CO_3(aq)$

Q3 **B** In a redox reaction the reductant provides the electrons to the oxidant which is reduced in the process.

Q4 **D** The Brønsted-Lowry theory defines an acid as a proton donor and a base as a proton acceptor.
Response B is also correct because a base can accept a proton from water leading to the formation of hydroxide ions but this is not the **best** response.

Q5 **B** n(CO_2) = V / V_m = 1.365 / 24.5 = 5.57×10^{-2} mol
n(MgO) = n(CO_2)
M(MgO) = 24.3 + 16.0 = 40.3 g mol^{-1}
m(MgO) = n × M = 5.57×10^{-2} × 40.3 = **2.245 g**

Q6 **A** The conjugate acid for the monohydrogen phosphate ion will have an additional proton therefore, $H_2PO_4^-(aq)$.
$$\underset{base_1}{HPO_4^{2-}(aq)} + \underset{acid_2}{H_2O(l)} \rightleftharpoons \underset{acid_1}{H_2PO_4^-(aq)} + \underset{base_2}{OH^-(aq)}$$

Q7 **D** In the greenhouse effect, increased levels of gases such as carbon dioxide and methane, inhibit the reflection of infrared radiation back into space thereby increasing the temperature.

Q8 **A** n(NaOH) = c × V = 0.100 × (20.0/1000) = 2.00×10^{-3} mol
n(OH^-) = n(NaOH) = 2.00×10^{-3} mol
c(OH^-) = [OH^-] = n / V = 2.00×10^{-3} / 2.00 = 1.00×10^{-3} M
$K_w = [H^+][OH^-] = 10^{-14}$
$[H^+] = 10^{-14}/ [OH^-] = 10^{-14} / 1.00\times10^{-3} = 1.00\times10^{-11}$ M
pH = $-\log_{10}[H^+] = -\log_{10}(1.00\times10^{-11}) = 11$

Q9 **A** Atom economy refers to the incorporation of the maximum proportion of the atoms from the reactant species in the product.

Q10 **D** When a **hydrogen carbonate** reacts with acid it forms **a salt, carbon dioxide and water**. Therefore the reaction between stoichiometric amounts of sodium hydrogen carbonate and nitric acid can be represented by the chemical equation

$$NaHCO_3(s) + HNO_3(aq) \rightarrow NaNO_3(aq) + CO_2(g) + H_2O(l)$$

Response B is not correct because sodium nitrate, like all common nitrate salts, is soluble in water.

Q11 **C** **Oxygen is produced on the industrial scale by separating it from air**. This is done by **fractional distillation of liquid air**. Air is mainly a mixture of nitrogen and oxygen, which have boiling temperatures of -196 ºC and -183 ºC respectively.
The electrolysis of water will produce both hydrogen and oxygen gases at different electrodes, but is not used as an industrial method of the production of oxygen.
The other two methods can be used in the laboratory to produce small quantities of oxygen.

Q12 **B** When ionic solids dissolve in water they dissociate into their ions and these ions can carry the electric current.

$$CuSO_4(s) \xrightarrow{H_2O} Cu^{2+}(aq) + SO_4^{2-}(aq)$$

Q13 **C** Plants cannot directly oxidise nitrogen to nitrate ions. The nitrogen fixing bacteria in the root nodules of some plants, such as the legumes, will fix nitrogen and form ammonium ions.
Nitrate ions can be formed from ammonium ions by the action of nitrifying bacteria in soils. When nitrogen oxides in the atmosphere react with water they can form nitric acid, which is a source of nitrate ions. Commercial nitrate based fertilisers can be produced by the oxidation of ammonia to from nitric acid.

Q14 **D** The appropriate half-equations from the Electrochemical series Table 2

$$Ag^+(aq) + e^- \rightleftarrows Ag(s)$$
$$Cu^{2+}(aq) + 2e^- \rightleftarrows Cu(s)$$
$$Ni^{2+}(aq) + 2e^- \rightleftarrows Ni(s)$$
$$Fe^{2+}(aq) + 2e^- \rightleftarrows Fe(s)$$
$$Zn^{2+}(aq) + 2e^- \rightleftarrows Zn(s)$$

Only the **oxidants stronger than the Ni^{2+} ion will be reduced** therefore only those above the nickel in the series will have a chemical reaction.

Tube I: $Ni(s) + Cu^{2+}(aq) \rightarrow Ni^{2+}(aq) + Cu(s)$

Tube IV: $Ni(s) + 2Ag^+(aq) \rightarrow Ni^{2+}(aq) + 2Ag(s)$

Q15 **B** n(Pb^{2+}) = 0.048 mol
n(Zn) = m / M = 3.01 / 65.4 = 0.046 mol
Since the mole ratio of the reactants is 1:1 the limiting quantity will be the mass of zinc.
n(Pb) = n(Zn) = 0.046 mol
m(Pb) = n × M = 0.046 × 207.2 = **9.5 g**

Q16 C The hydrogen selenate ion can act as either an acid and donate a proton to form selenate ions, or as a base and accept a proton to form selenic acid. Therefore the **hydrogen selenate ion** has **amphiprotic properties**.

$$HSeO_4^-(aq) + H_2O(l) \rightleftharpoons SeO_4^{2-}(aq) + H_3O^+(aq)$$

$$HSeO_4^-(aq) + H_2O(l) \rightleftharpoons H_2SeO_4(aq) + OH^-(aq)$$

Q17 B Since the temperature and pressure are the same, then the volume ratio is the same as the mole ratio.

$V(O_2) = {}^5/_3 \times V(CO_2) = {}^5/_3 \times 3.6 =$ **6.0 L**

Q18 A $n = V / V_m = 14.9 / 24.5 = 0.608$ mol

$M = m / n = 18.27 / 0.608 =$ **30.0 g mol⁻¹.**

$M(C_2H_6) = 2\times12.0 + 6\times1.0 =$ **30.0 g mol⁻¹.**

$M(C_3H_8) = 3\times12.0 + 8\times1.0 = 44.0\ g\ mol^{-1}$.

$M(NH_3) = 14.0 + 3\times1.0 = 17.0\ g\ mol^{-1}$.

$M(HCN) = 1.0 + 12.0 + 14.0 = 27.0\ g\ mol^{-1}$.

Q19 B $n(H^+) = 2\times0.50 = 1.0$ mol

$$Na_2CO_3(s) + 2H^+(aq) \rightarrow 2Na^+(aq) + CO_2(g) + H_2O(l)$$

$n(Na_2CO_3) = ½\ n(H^+) = ½ \times 1.0 =$ **0.50 mol**

Q20 C Coating steel (iron) with zinc is an example of sacrificial corrosion protection because **zinc is a stronger reductant than iron** and will be **oxidised in preference to the iron during corrosion**.

Q21 B $n(Ba(OH)_2) = c \times V = 0.126 \times (10.00/1000) = 1.26\times10^{-3}$ mol

From the chemical equation

$$Ba(OH)_2(aq) + 2HCl(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$$

$n(HCl) = 2n(Ba(OH)_2) = 2 \times 1.26\times10^{-3} = 2.52\times10^{-3}$ mol

$c(HCl) = n / V = 2.52\times10^{-3} / (26.53/1000) =$ **0.0950 M**

Q22 D **In aqueous solutions of strong acids, the majority of the acid species has ionised** and donated its proton to the water molecules. If a strong acid is represented as HA, then the ionisation can be represented by the chemical equation

$$HA(aq) + H_2O(l) \rightarrow A^-(aq) + H_3O^+(aq)$$

In a weak acid only a small proportion of the acid has ionised, the majority of the acid species is unionised.

The concentration of an acid does not reflect the acid strength, only how much of the acid is present in the solution. An aqueous solution of a strong acid can be quite dilute and as a result it will have a low concentration of $H_3O^+(aq)$ ions.

Q23 C Photochemical smog involves the reaction of nitrogen oxides with unburnt hydrocarbons from pollution. Oxygen in the atmosphere will oxidise any nitrogen(II) oxide formed in internal combustion engines to form nitrogen(IV) oxide. Carbon dioxide plays no role in the formation of the smog.

Q24 B The 1997 Kyoto protocol is an international agreement designed to limit and reduce greenhouse gas emissions.

Short Answer (Answers) - Section B

Question 1 (8 marks, 10 minutes)

a. i. In this reaction the **oxidation state of the lithium changes from zero (0) in the lithium metal to +1 in lithium hydroxide**, therefore this reaction is a **reduction oxidation, redox, reaction**. **(1 mark)** The lithium metal is being **oxidised** while the water is being **reduced**. The chemical half-equations for this reaction are

$$Li(s) \rightarrow Li^{+}(aq) + e^{-}$$

$$2H_2O(l) + 2e^{-} \rightarrow 2OH^{-}(aq) + H_2(g)$$

ii. In this reaction the water is acting as the **oxidant**. **(1 mark)**

b. i. $Li_2O(s) + H_2O(l) \rightarrow 2LiOH(aq)$ **(1 mark)** or

$$Li_2O(s) + H_2O(l) \rightarrow 2Li^{+}(aq) + 2OH^{-}(aq)$$

ii. This is an acid-base reaction as a proton is being donated to the oxide ion to form the hydroxide ion. In this reaction water is providing the proton so it is acting as **an acid**. **(1 mark)**

c. i. The General Gas Equation: PV = nRT

T = 273 + 18.3 = 291.3 K

$n(H_2) = \dfrac{PV}{RT} = \dfrac{107.5 \times 1.247}{8.31 \times 291.3}$ = **5.54×10^{-2} mol (1 mark)**

ii. $n(Li) = 2 \times n(H_2) = 2 \times 5.54 \times 10^{-2} = 1.11 \times 10^{-1}$ mol

$m(Li) = n \times M = 1.11 \times 10^{-1} \times 6.9$ = **0.76 g (1 mark)**

iii. $m(Li_2O)$ = m(sample) - m(Li) = 1.225 - 0.76 = 0.47 g **(1 mark)**

$\%(Li_2O) = \dfrac{0.47}{1.225} \times \dfrac{100}{1}$ = **38 % (1 mark)**

Question 2 (9 marks, 11 minutes)

a. i. From the solubility curve, the solubility of disodium hydrogen phosphate at 40 ºC is 64 g/100 mL, therefore the minimum mass of solid disodium hydrogen phosphate required to prepare 250.0 mL of solution would be

$m(Na_2HPO_4) = (64/100) \times 250.0$ = **160 g (1 mark)**

ii. $M(Na_2HPO_4) = 2 \times 23.0 + 1.0 + 31.0 + 4 \times 16.0 = 142.0$ g mol^{-1}.

$n(Na_2HPO_4)$ = m / M = 160 / 142.0 = 1.1 mol

$c(Na_2HPO_4)$ = n / V = 1.1 / (250/1000) = 4.4 M **(1 mark)**

When solid disodium hydrogen phosphate dissolves in water it dissociates

$$Na_2HPO_4(s) \xrightarrow{H_2O} 2Na^{+}(aq) + HPO_4^{2-}(aq)$$

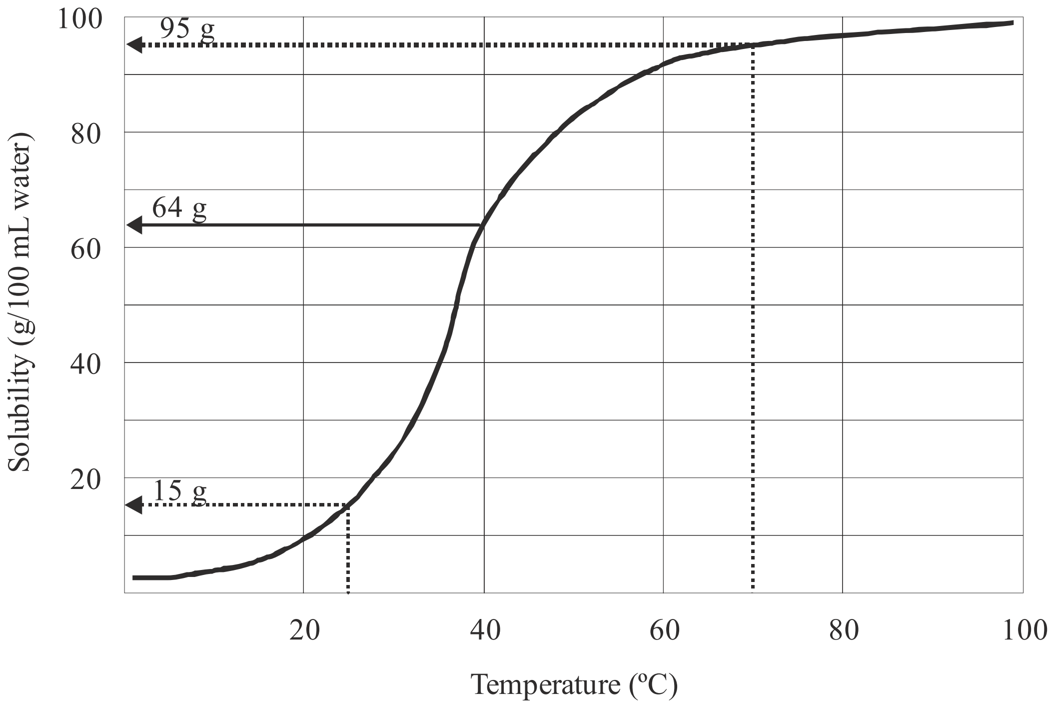
$c(HPO_4^{2-}) = c(Na_2HPO_4)$ = **4.4 M (1 mark)**

iii. From the solubility curve, the solubilities of disodium hydrogen phosphate at 70 ºC and 25 ºC are 95 g/100 mL and 15 g/100 mL, therefore for 100 mL the amount of solid that should crystallise from solution should be

$m(Na_2HPO_4$, from 100 mL) = 95 - 15 = 80 g **(1 mark)**

For the 50.0 mL sample, the mass of solid that the students would expect to collect when they filtered the cooled solution is

$m(Na_2HPO_4) = (80/100) \times 50$ = **40 g (1 mark)**



b. i. Both animals and plants require oxygen for respiration, and as the temperature of the water increases, then the **amount of dissolved oxygen available decreases**. Aquatic plants also require carbon dioxide for photosynthesis and the **amount of dissolved carbon dioxide also decreases with increasing temperature**. **(1 mark)**

ii. During hot weather the **water temperature will increase** and this will **reduce the amount of dissolved gases available** to the aquatic life. Also the increased temperature will **increase the growth of plants and the activity of animals, further increasing the demand for oxygen** and as a result the **quality of life in the pond will decline**. **(1 mark)**

iii. It is necessary to aerate the water so that the **dissolved oxygen level in the aquarium remains as high as possible because the goldfish consume this oxygen during respiration**. **(1 mark)** Bubbling air through water provides a better aeration than is available at the water-air surface interface.

iv. Increasing the water temperature of the oceans by only a few degrees will mean that **less carbon dioxide from the atmosphere can be dissolved in the water**. **(1 mark)**

Question 3 (8 marks, 10 minutes)

a. i. The key group of industrially produced chemicals that have been identified as contributing to the depletion of ozone in the upper atmosphere are the **chlorofluorocarbons, CFCs. (1 mark)** Other chemicals have been identified as contributing to the depletion, such as nitrogen oxides, but these are not industrially produced, but are by-products of other processes such as the burning of fuel in jet engines.

ii. A number of possible answers for the properties of CFCs that made them popular for use in society. **(1 mark for a correct response)**
They are **non-flammable**, and were used as fire extinguishing agents.
They are **very stable** under most conditions.
They are **non-toxic**.
They can be easily compressed and vaporise making them **useful as refrigerants**.
Their ease of compression and vaporisation made them **useful as propellants in aerosol, pressure pack, cans.**

iii. More **ultraviolet radiation is reaching the surface of the Earth** and as a consequence there has been an **increased risk of skin cancer** in people and animals. **(1 mark)** Also increased ultraviolet radiation can cause damage to crops, lowering the yield obtained.

iv. The **Montreal protocol** and other agreements have seen the **phasing out of ozone depleting CFCs** and their replacement with other alternative chemicals.
(1 mark) For example the propellant used in most aerosol cans today is butane. This is not as safe as CFC's, because this gas is flammable and more toxic. However it does not act as an ozone depleting agent in the upper atmosphere.

b. i. A number of possible alternatives.
(Mark allocation: 1 mark a correct answer. Total 2 marks)
Respiration
Photosynthesis
Combustion
Aerobic decomposition
Anaerobic decomposition
Fermentation

ii. **(1 mark allocated)**
Respiration - This process occurs in both animals and plants where glucose is oxidised by oxygen from the atmosphere to produce carbon dioxide gas and water.

$$C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$$

Photosynthesis - This process occurs in plants where carbon dioxide is removed from the atmosphere and oxygen released into it while the plant produces glucose.

$$6CO_2(g) + 6H_2O(l) \xrightarrow[\text{chlorophyll}]{\text{light}} C_6H_{12}O_6(aq) + 6O_2(g)$$

Combustion - The burning of carbon-containing fuels, fossil fuels or wood, that removes oxygen and adds carbon dioxide to the atmosphere. Other gases such as unburnt hydrocarbons and carbon monoxide can be released as well as particles such as soot.

$$C_7H_{16}(g) + 11O_2(g) \rightarrow 7CO_2(g) + 8H_2O(l)$$

Aerobic decomposition - The decomposition of animal and/or vegetable waste in the presence of air that releases carbon dioxide into the atmosphere.
Anaerobic decomposition - The decomposition of animal and/or vegetable waste in the absence of air that will release carbon dioxide and methane into the atmosphere.
Fermentation - The action of yeast on glucose and sugars that releases carbon dioxide into the atmosphere.

$$C_6H_{12}O_6(aq) \xrightarrow{\text{yeasts}} 2CH_3CH_2OH(aq) + 2CO_2(g)$$

iii. Over the last 200 years, society has **burnt more fossil fuels** to provide it with a source of energy and as a result **increased the level of carbon dioxide in the atmosphere**. **(1 mark)**
Other alternatives could include.
Over the past 200 years agricultural practices have become more intense and this has contributed to an increase in greenhouse gases in the atmosphere.
The population of the Earth has increased and the larger population has required more energy and this has increased carbon dioxide emissions.

Question 4 (9 marks, 11 minutes)

a. i. H_2SO_3 is a weak diprotic acid, this means that it can donate two protons to water in successive ionisation reactions, both of which do not go to completion.

$H_2SO_3(aq) + H_2O(l) \rightleftharpoons HSO_3^-(aq) + H_3O^+(aq)$ **(1 mark)**

$HSO_3^-(aq) + H_2O(l) \rightleftharpoons SO_3^{2-}(aq) + H_3O^+(aq)$ **(1 mark)**

ii. Because it is a weak acid most of the sulfurous acid will not have ionised, therefore the sulfur containing species with the highest concentration will be **H_2SO_3. (1 mark)** In a 0.1 M aqueous solution the molar percentage concentrations of the H_2SO_3, HSO_3^- and SO_3^{2-} are 69.1 %, 30.9 %, and less than 0.1 % respectively.

b. $MgO(s) + 2CH_3COOH(aq) \rightarrow Mg(CH_3COO)_2(aq) + 2H_2O(l)$ **(1 mark)** or

$MgO(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2O(l)$

c. n(HCl) = c × V = 0.10 × (500.0/1000) = 0.050 mol
n(NaOH) = c × V = 0.050 × (500.0/1000) = 0.025 mol
The reaction between sodium hydroxide and hydrochloric acid is

$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

Therefore the HCl is in excess
n(HCl, excess) = 0.050 - 0.025 = 0.025 mol **(1 mark)**
The total volume of the mixture is 1000.0 mL = 1.00 L
$[H^+] = c(H^+) = c(HCl) = n / V = 0.025 / 1.00 = 0.025$ M
$pH = -\log_{10}[H^+] = -\log_{10}(0.025) =$ **1.6 (1 mark)**

d. $Ca(OH)_2(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$

i. n(HCl) = c × V = 0.249 × (25.60/1000) = **6.37×10^{-3} mol (1 mark)**

ii. From the chemical equation the stoichiometry of the reaction:
$n(Ca(OH)_2) = \frac{1}{2} n(HCl) = \frac{1}{2} \times 6.37\times10^{-3} = 3.19\times10^{-3}$ mol
$M(Ca(OH)_2) = 40.1 + 2\times16.0 + 2\times1.0 = 74.1$ g mol^{-1}
$m(Ca(OH)_2) = n \times M = 3.19\times10^{-3} \times 74.1 =$ **0.236 (1 mark)**

iii. $\%(Ca(OH)_2) = 0.236/0.381 \times 100/1 =$ **62.0 % (1 mark)**

Question 5 (9 marks, 11 minutes)

a. i. The diagram must show that the electrodes are the appropriate metals namely Ag and Co and that the electrolytes are $Ag^+(aq)$ and $Co^{2+}(aq)$. **(1 mark)** *The concentration of 1 M is not required for the mark.*

ii. From the electrochemical series data (Table 2 VCE Data Booklet) the appropriate half-equations are:

$Ag^+(aq) + e^- \rightleftarrows Ag(s)$

$Co^{2+}(aq) + 2e^- \rightleftarrows Co(s)$

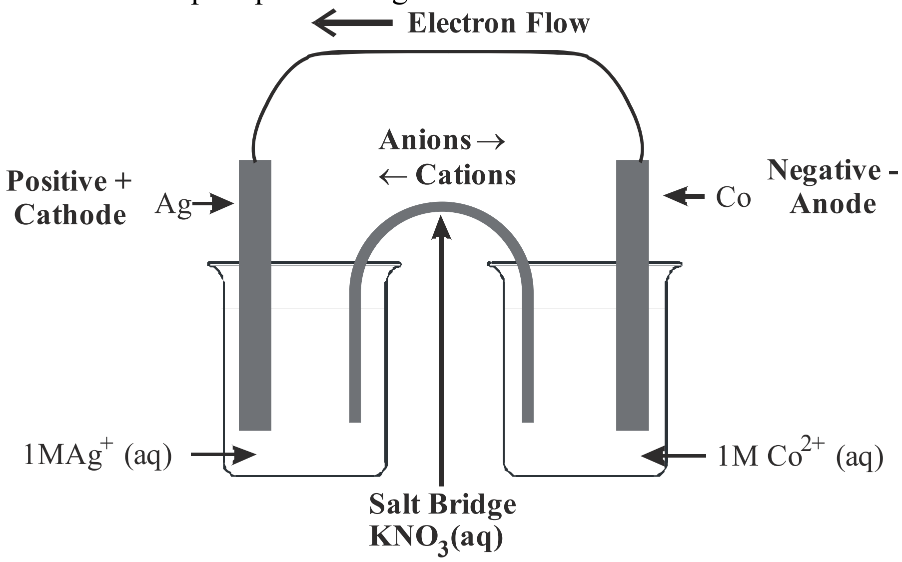
From this data the $Ag^{+}(aq)$ ion is the stronger oxidant and will be reduced and the Co is the stronger reductant and will be oxidised. Therefore the Ag electrode will be positive and the Co electrode negative. **(1 mark)**

iii. Oxidation occurs at the Co anode and reduction occurs at the Ag cathode. **(1 mark)**

iv. The electrons will flow from the **anode through the external circuit to the cathode**. **(1 mark)**

v. The anions will flow from the salt bridge into the half-cell containing the anode and the cations into the half-cell containing the cathode. **(1 mark)**

vi. The most suitable material for the salt bridge electrolyte is an aqueous solution of potassium nitrate. **(1 mark)**
Other possible alternatives include: $NaNO_3(aq)$, $NH_4NO_3(aq)$.
The chloride salts of ammonium, potassium or sodium could be used but these will result in a precipitate of AgCl.



b. From the electrochemical series data (Table 2 VCE Data Booklet) the appropriate half-equations will be:

$Ag^{+}(aq) + e^{-} \rightarrow Ag(s)$

$Co(s) \rightarrow Co^{2+}(aq) + 2e^{-}$

The overall equation is the sum of the two half-equations so that the number of electrons produced and consumed is the same.

$Co(s) + 2Ag^{+}(aq) \rightarrow Co^{2+}(aq) + 2Ag(s)$ **(1 mark)**

c. The corrosion of iron is an electrochemical reaction where the iron acts as the reductant and oxygen acts as the oxidant. The appropriate electrochemical equation for the initial stage of corrosion is

$2Fe(s) + O_2(aq) + 2H_2O(l) \rightarrow 2Fe(OH)_2(s)$

Factors increasing the rate of corrosion of iron in steel are:
The presence of ions from dissolved salts or acidic pollutants in the water. **(1 mark)**
These impurities result in the water being a better electrolyte and can increase the rate of corrosion of the iron.
The presence of impurities, such as carbon in the iron. **(1 mark)** These can act as cathodes to facilitate the reduction of the oxygen.

Question 6 (8 marks, 10 minutes)

a. The pressure of a gas is due to the collisions of the gas particles with the walls of the container.

i. Increasing the amount of gas directly increases the number of gas particles and as a result will **increase the number of collisions** between the particles and the walls of the container, thereby directly increasing the pressure. **(1 mark)** This can be seen in the general gas equation for a fixed volume vessel at constant temperature **P**V = **n**RT.

ii. Lowering the temperature will **decrease the average kinetic energy** of the gas particles and hence their speed. This will **reduce the number of times that they collide with the walls** of the container, thereby resulting in a **decrease in pressure**. **(1 mark)**

b. Pressure is the force exerted and will depend on the number of heavy blocks in this example. Using Boyle's Law **PV = *k***

$P_1V_1 = P_2V_2$: $5 \times 0.50 = 3 \times V_2$

$V_2 = 2.5 / 3 =$ **0.83 L (1 mark)**

c. The total pressure of a gas is the sum of the individual gas pressures.

$P_T = P(H_2) + P(H_2O)$

$P(H_2) = 106.3 - 2.30 = 104.0$ kPa **(1 mark)**

Using the combined gas equation

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{104.0 \times 56.0}{293} = \frac{101.3 \times V_2}{298}$$

$V_2 = \dfrac{104.0 \times 56.0 \times 298}{293 \times 101.3} =$ **58 L (1 mark)**

d. i. The complete combustion of a hydrocarbon produces carbon dioxide and water. Write down chemical equation showing reactants and products.

$CH_4(g) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$

Balance carbon and hydrogen atoms

$CH_4(g) + O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

Balance oxygen atoms

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ **(1 mark)**

ii. From the chemical equation there are three mole of reactant gases and 1 mol of product gas, therefore the pressure inside the vessel at the end will be $^1/_3$ the original pressure. **(1 mark)**

P = 101.3 / 3 = **33.77 kPa (1 mark)**

End of Suggested Answers