VCE CHEMISTRY 2008

YEAR 11 TRIAL EXAM UNIT 2

Time allowed: 90 minutes
Total marks: 74

24 Multiple Choice Questions
6 Short Answer Questions

An Answer Sheet is provided for Section A.
Answer all questions in Section B in the space provided.

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 2008 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 questions 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 2008 Year 11 Trial Exam Unit 2

Multiple Choice Questions

Section A – (24 marks, 29 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.)*

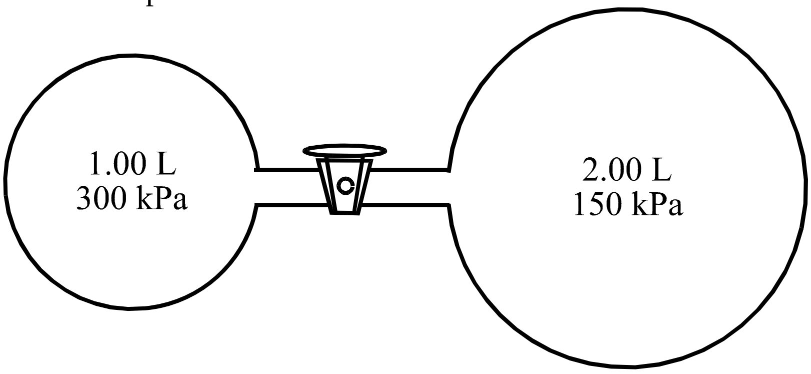
Question 1
A supersaturated solution is one where the mass of solute dissolved in a given volume of solvent is
A. more than the mass of solute that is soluble at a given temperature.
B. equal to the mass of solute that is soluble at a given temperature.
C. less than the mass of solute that is soluble at a given temperature.
D. more than the maximum mass of solute that will dissolve at the standard temperature.

Question 2
Which one of the following gases will contribute most to the formation of acid rain?
A. $CH_4(g)$
B. $N_2(g)$
C. $SO_2(g)$
D. $CO(g)$

Question 3
In a reduction oxidation, redox, reaction the reductant
A. loses electrons and is itself reduced.
B. is reduced and gains electrons.
C. gains electrons and is itself oxidised.
D. is oxidised and loses electrons.

Question 4
The heat of vaporisation for water is 44 kJ mol^{-1}, this is higher than that for many other substances with similar molar masses. The main contribution to this relatively high value is the energy required to break the
A. covalent bonds within the water molecules.
B. covalent bonds between the water molecules.
C. hydrogen bonds within the water molecules.
D. hydrogen bonds between the water molecules.

Question 5
Two samples of argon gas are stored in separate flasks joined together by a tap as shown in the diagram below. What would be the pressure of the argon inside either flask when the tap between the two flasks is opened?



A. 225 kPa.
B. 150 kPa.
C. 200 kPa.
D. 175 kPa.

Question 6
A group of VCE chemistry students evaporated a 120 mL sample of an aqueous sodium chloride solution and obtained 2.158 g of solid. The chloride ion concentration of this solution was
A. 0.507 M.
B. 0.0369 M.
C. 0.307 M.
D. 0.614 M.

Question 7
Sapphire Energy in the USA have reported the production of petrol, diesel and jet fuel from a genetically engineered strain of algae. This is an example of green chemistry because it
A. will reduce greenhouse gas emissions when used.
B. will not produce any waste during the refining process.
C. uses a renewable material to replace fossil fuels.
D. will maximise the atom economy of the refining process.

Question 8
The complete combustion of methanol can be represented by the chemical equation
$2CH_3OH(g) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$
In a reaction that produced 5.6 L of carbon dioxide the volume of oxygen required at the same temperature and pressure would be
A. 8.4 L.
B. 3.7 L.
C. 5.6 L.
D. 16.8 L.

Question 9

The chemical reaction that occurs when copper(II) nitrate is heated can be described by the chemical equation

$$2Cu(NO_3)_2(s) \rightarrow 2CuO(s) + 4NO_2(g) + O_2(g)$$

The mass of solid that would remain in a test tube when 18.76 g of copper(II) nitrate was heated would be

A. 11.9 g.

B. 10.8 g.

C. 7.96 g.

D. 15.9 g.

Question 10

Nitrogen is an essential element for living things and is required for the production of large biomolecules such as proteins and DNA. Which one of the following statements is **incorrect** about the nitrogen cycle?

A. Bacteria in the soil can oxidise ammonium ions to nitrate ions.

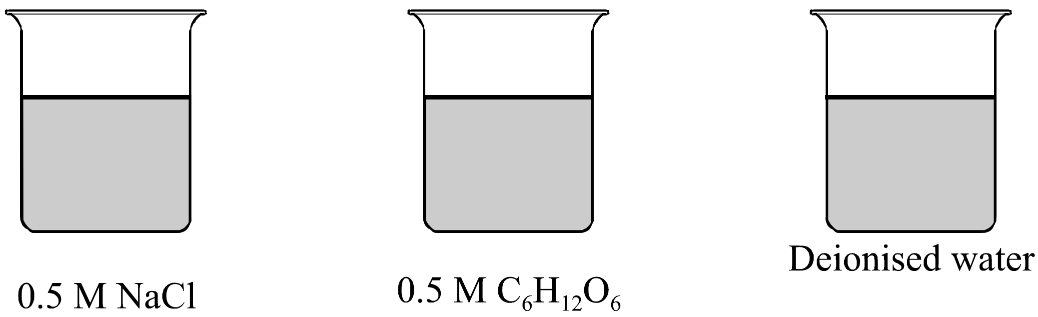
B. Lightning can assist in the fixing of atmospheric nitrogen by providing the energy required to form nitrogen oxides.

C. Synthetic fertilisers can be made from atmospheric nitrogen by using the Haber process to produce ammonia.

D. Plants can absorb nitrogen directly from the atmosphere to produce proteins.

Question 11

A student had three beakers as shown in the diagram below.



Which one of the following statements is **not** correct about the electrical conductivity of these three solutions?

A. The sodium chloride solution will be the best electrical conductor because the solute provides electrons that can conduct a current.

B. The electrical conductivity of the deionised water and the glucose solution will be small.

C. The electrical conductivity of the sodium chloride solution will be significantly greater than that for the other two.

D. The very weak electrical conductivity for the deionised water is due to the small amount of self-ionisation that water undergoes.

Question 12
An aqueous solution of ammonia, NH_3, that is used for cleaning purposes has a pH of 12 at 25 ºC. In a 500 mL sample of this solution the concentration of the hydroxide, $OH^-(aq)$, ions will be
A. 10^{-13} M.
B. 10^{-12} M.
C. 10^{-2} M.
D. 10^{-3} M.

Question 13
One of the chemical half-equations that describes what occurs when a piece of zinc metal is placed in an aqueous solution of iron(II) sulfate is
A. $Zn(s) \rightarrow Zn^{+}(aq) + e^{-}$
B. $Fe^{2+}(aq) + 2e^{-} \rightarrow Fe(s)$
C. $Zn^{2+}(aq) + 2e^{-} \rightarrow Zn(s)$
D. $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^{-}$

Question 14
The heat capacity for a substance is the amount of energy required to
A. heat a substance to its boiling temperature.
B. increase the temperature of the substance by 1 ºC without changing its state.
C. change a substance from its liquid to gas state.
D. increase the temperature of the substance by 1 ºC while changing its state.

Question 15
An historical iron artefact was buried in the thick mud at the bottom of a fresh water lake. When this artefact is recovered it may
A. be significantly corroded due to its continued immersion in water.
B. be significantly corroded because any ions in the water would increase the rate of corrosion.
C. not show significant corrosion because the mud may have provided an environment where the oxygen concentration is low.
D. not show significant corrosion because there are few dissolved chloride ions in the lake water.

Question 16
When an aqueous solution of copper(II) sulfate is added to which one of the following aqueous solutions will a precipitate **not** be expected to form?
A. Sodium carbonate.
B. Barium chloride.
C. Ammonium chloride.
D. Silver nitrate.

Question 17

A group of students investigated the reactivity of three metals, X, Y and Z with aqueous solutions containing their corresponding ions, X^{2+}, Y^{2+} and Z^{2+}. They found that; metal X reacted with Y^{2+} but not Z^{2+}, and metal Z reacted with both Y^{2+} and X^{2+}.

What is the order of the metals from weakest reductant to strongest reductant?

A. X, Y, Z.
B. Y, Z, X.
C. Z, Y, X.
D. Y, X, Z.

Question 18

250 mL of an aqueous 0.10 M sodium hydroxide solution was mixed with 500 mL of an aqueous 0.050 M potassium hydroxide solution. What is the hydroxide ion concentration of the mixture?

A. 0.15 M.
B. 0.067 M.
C. 0.033 M.
D. 0.058 M.

Question 19

The reaction between solid calcium carbonate and dilute nitric acid can be represented by the chemical equation

$$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

A 2.894 g sample of calcium carbonate was added to 500.0 mL of 0.100 M nitric acid and allowed to react. At the completion of the reaction

A. 3.91×10^{-3} mol of calcium carbonate would remain.
B. 7.82×10^{-3} mol of calcium carbonate would remain.
C. 1.10×10^{-2} mol of nitric acid would remain.
D. 2.11×10^{-2} mol of nitric acid would remain.

Question 20

The kinetic molecular theory is a model that can be used to explain the behaviour of gases. Which one of the following statements is **not** consistent with this model?

A. Gases can readily diffuse to fill a containing vessel because the particles are moving rapidly in straight lines.
B. The kinetic energy of all of the particles in a gas sample will be the same at a given temperature.
C. Gases can be easily compressed because they are made up of small particles whose total volume is significantly less than the volume that they occupy.
D. The pressure of a gas sample within a sealed vessel is due to the collisions of the gas particles with the walls of the vessel.

Question 21

The fertiliser ammonium nitrate, NH_4NO_3, is readily soluble in water, because the water molecules will form

A. dipole-dipole interactions with the ammonium nitrate molecules.
B. hydrogen bonds with the ammonium nitrate molecules.
C. dipole-dipole interactions with the ammonium and nitrate ions.
D. ion-dipole interactions with the ammonium and nitrate ions.

Question 22

The diagram shows two beakers containing aqueous solutions of hydrochloric and ethanoic acids with the same solute concentrations.

500 mL 0.10 M HCl   500 mL 0.10 M CH_3COOH

The pH of the hydrochloric acid solution will be

A. less than that of the ethanoic acid because it is a strong acid and ionises completely giving a higher $[H_3O^+(aq)]$.

B. less than that of the ethanoic acid because it is a weak acid and only partially ionises giving a lower $[H_3O^+(aq)]$.

C. greater than that of the ethanoic acid because it is a weak acid and only partially ionises giving a lower $[H_3O^+(aq)]$.

D. greater than that of the ethanoic acid because it is a strong acid and ionises completely giving a higher $[H_3O^+(aq)]$.

Question 23

The ammonium ion, $NH_4^+(aq)$, is an acid. The conjugate base for this ion is

A. $H_2O(l)$.

B. $NH_3(aq)$.

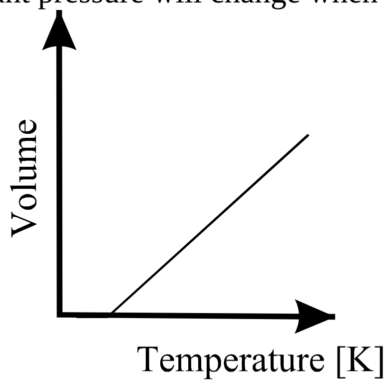
C. $OH^-(aq)$.

D. $NH_2^-(aq)$.

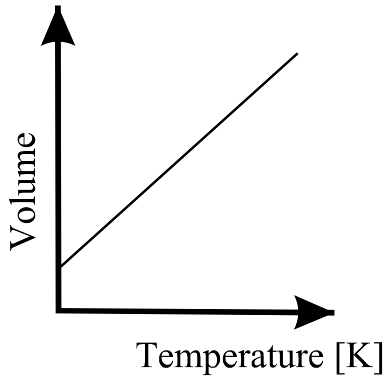
Question 24

Which one of the following graphs best represents how the volume of a sample of an ideal gas at constant pressure will change when the temperature is changed?

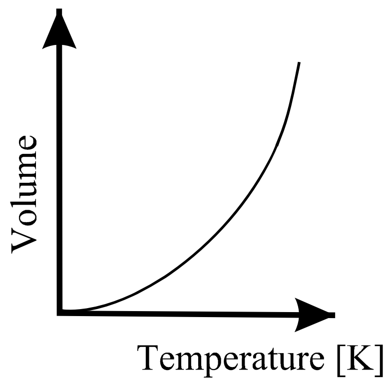
A.



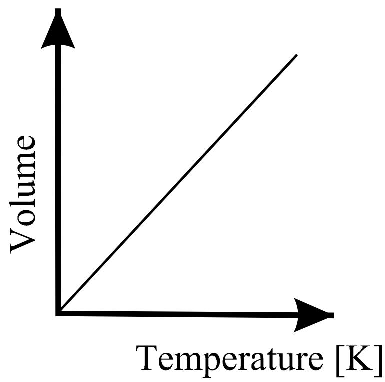
B.



C.



D.



End of Section A

VCE Chemistry 2008 Year 11 Trial Exam Unit 2

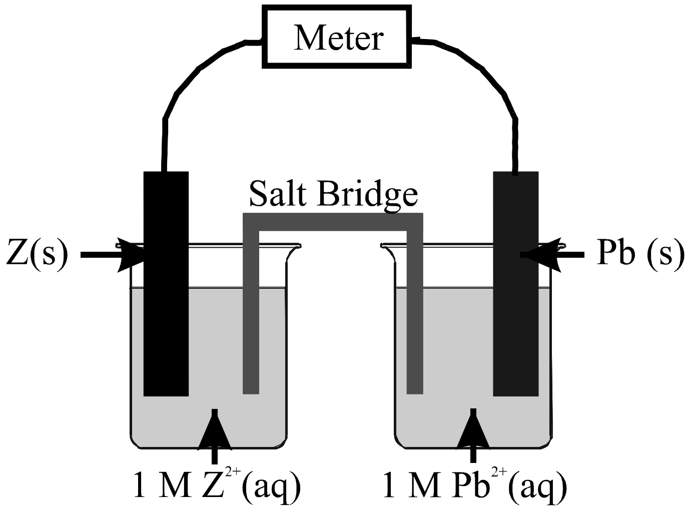
Short Answer Questions – Section B

(50 marks, 61 minutes)

This section contains four 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 - (11 marks, 13 minutes)

a. As part of an extended experimental investigation on the redox reactions of metals a group of VCE chemistry students set up a number of galvanic cells similar to the one shown in the diagram below. Each cell contained the Pb^{2+}/Pb half-cell.



Use the electrochemical series data to predict the reactions that would occur in the following cells.

	Z^{2+}/Z half-cell	
	Cu^{2+}/Cu	Fe^{2+}/Fe
Type of half-reaction occurring at the Pb electrode.		
Oxidant		
Reductant		
Half-equation for the reaction occurring at the Z electrode.		
Overall chemical equation for the reaction occurring in the cell.		

(6 marks)

b. The wet corrosion of iron involves two steps to form rust.

i. What is the oxidant in both of these steps?

(1 mark)

ii. What is the reductant in the first stage of this process?

(1 mark)

iii. Write the chemical half-equation for the oxidation reaction that occurs during the first stage of the rusting process.

(1 mark)

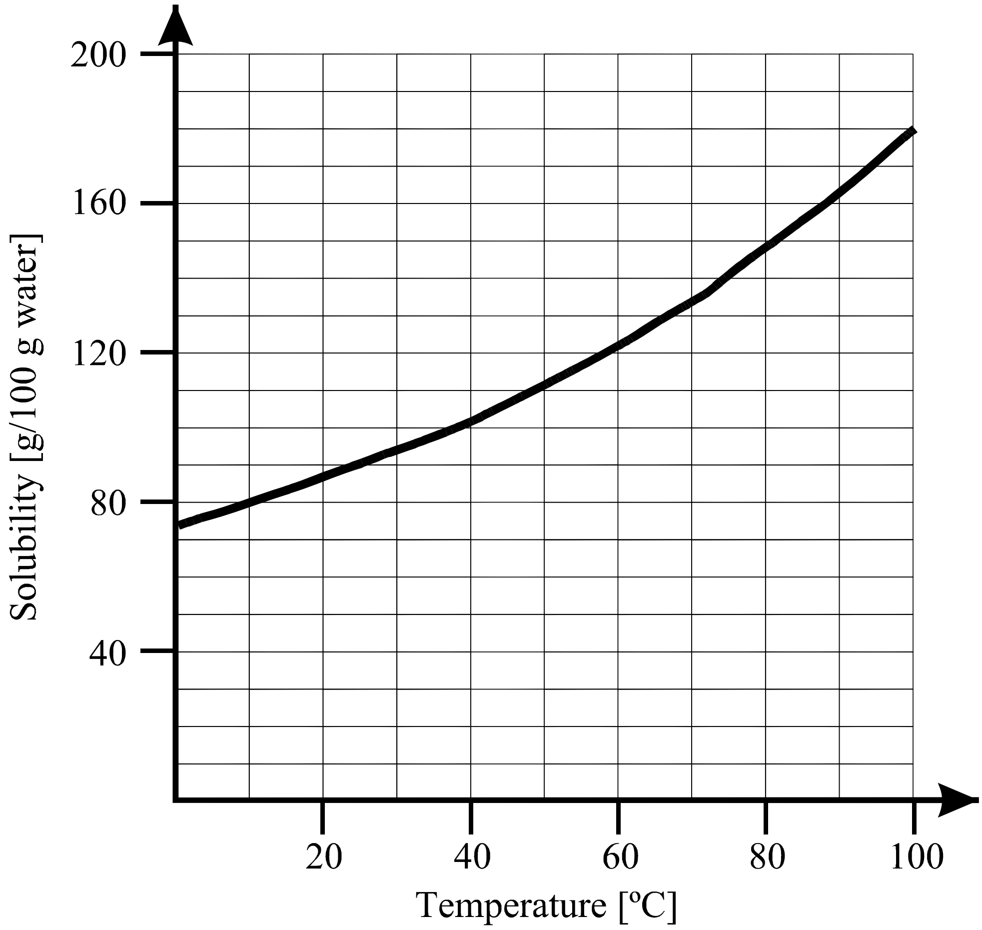
iv. Write the chemical half-equation for the reduction reaction that occurs during both stages of the rusting process.

(1 mark)

v. What is the insoluble product formed during the first stage of the rusting process?

(1 mark)

Question 2 (7 marks, 9 minutes)
The solubility curve for sodium nitrate, $NaNO_3$, is shown.
(Assume the density of water is 1.0 g mL^{-1}.)



a. What is the minimum temperature required to completely dissolve 350 g of sodium nitrate in 250 mL of water?

(2 marks)

b. A saturated solution of sodium nitrate was prepared by dissolving the required mass of solute in 1.00 L of water at 25 ºC. How many sodium ions are present in this solution?

(3 marks)

c. A student had prepared a solution of sodium nitrate by dissolving 23.0 g of solute in 20.0 mL of water. When the solution was at 45 ºC the student added a few crystals of solute. What should the student expect to observe when these crystals are added to this solution?

(2 marks)

Question 3 (8 marks, 10 minutes)

a. The water supplies to most households in Australia's main cities are treated by a number of processes two of which are flocculation and chlorination.

i. What does the flocculation process involve and what does it remove from the water?

(2 marks)

ii. Why are water supplies chlorinated?

(1 mark)

b. Water in some parts of Australia is referred to as being 'hard'.

i. What causes these water supplies to be hard?

(1 mark)

ii. How do soaps behave when used with 'hard' water?

(1 mark)

c. The proposed construction of Victoria's first desalination plant near Wontaggi has drawn significant media attention.

i. What does desalination involve?

(1 mark)

ii. What is one of the commonly used large scale desalination processes?

(1 mark)

iii. Briefly explain how the process listed in ii. above works.

(1 mark)

Question 4 (11 marks, 13 minutes)

a. Write appropriate chemical equations for the following.

i. The reaction between zinc metal and an aqueous solution of sulfuric acid.

(1 mark)

ii. The reaction that occurs when vinegar (ethanoic acid) is added to solid sodium hydrogen carbonate.

(1 mark)

iii. The reaction that occurs when aqueous solutions of barium hydroxide and nitric acid are mixed.

(1 mark)

iv. The hydrogen sulfate ion, HSO_4^-, acting as a weak base in an aqueous solution.

(1 mark)

b. Ammonia, NH_3, is a weak base present in some cleaning products. The reaction between aqueous solutions of ammonia and hydrochloric acid can be represented by the chemical equation

$$NH_3(aq) + HCl(aq) \rightarrow NH_4Cl(aq)$$

A student added deionised water to a 10.00 mL sample of an ammonia based cleaning product until the total volume of the mixture was 100.00 mL. The student then used volumetric techniques to analyse this diluted solution. The average volume of 0.100 M aqueous hydrochloric acid solution required to neutralise a 20.00 mL sample of the diluted solution was 23.56 mL.

i. How many mol of hydrochloric acid was added to the 20.00 mL sample?

(1 mark)

ii. How many mol of ammonia were present in the 20.00 mL sample?

(1 mark)

iii. How many mol of ammonia were present in the original 10.00 mL sample?

(1 mark)

iv. What mass of ammonia was dissolved in this original 10.00 mL sample?

(1 mark)

c. An aqueous sodium hydroxide solution was prepared by dissolving 0.200 g of solute in 500.0 mL of deionised water.

i. What is the concentration of this solution?

(1 mark)

ii. What would be the pH of this solution at 25 ºC?

(2 marks)

Question 5 (7 marks, 9 minutes)

a. Oxygen can be prepared in the laboratory by decomposing an aqueous solution of hydrogen peroxide in the presence of a manganese(VI) oxide catalyst. This reaction can be represented by the chemical equation

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

i. What volume of oxygen gas, at standard laboratory conditions, could be prepared from a 600.0 mL sample of a 1.80 M hydrogen peroxide solution?

(2 marks)

ii. What is a simple test that can be used in the laboratory to identify oxygen gas?

(1 mark)

b. A gas sample has a mass of 2.180 g and occupies a volume of 0.756 L at 155 kPa and 24.6 ºC.

i. How many mol of gas are present in the sample?

(1 mark)

ii. What is the molar mass of this gas?

(1 mark)

c. i. What are the two main gaseous pollutants that lead to the formation of photochemical smog in the lower atmosphere over many cities?

(1 mark)

ii. What is the main source of these pollutants?

(1 mark)

Question 6 (6 marks, 7 minutes)

Four of the 12 principles of green chemistry proposed by Paul Anastas and John Warner are:

Prevent waste.
Maximise atom economy.
Use safer solvents and reaction conditions.
Design for degradation

a. Briefly explain what is meant by the term atom economy.

(1 mark)

b. Why is it better to prevent waste in a process?

(1 mark)

c. i. What is one solvent that has been used to successfully replace chlorinated hydrocarbons in some processes?

(1 mark)

ii. Why is it necessary to replace chlorinated hydrocarbon solvents that have been successfully used in many processes for long periods of time?

(1 mark)

d. i. How would designing a product for degradation help the environment?

(1 mark)

ii. If a product cannot be designed to degrade, then what other environmental principle should this product ideally have?

(1 mark)

End of Section B

End of Trial Exam

Suggested Answers

VCE Chemistry 2008 Year 11 Trial Exam Unit 2

Multiple Choice Answers – Section A

(1 mark per question)

Q1 **A** A supersaturated solution is one where the mass of solute dissolved in the solvent is greater than the solubility of the solute at the temperature.

Q2 **C** Sulfur dioxide, SO_2, will dissolve in water droplets in the atmosphere to form sulfurous acid, H_2SO_3. Additionally it can be oxidised in the atmosphere to form sulfur trioxide, SO_3, which will also dissolve in water droplets to form sulfuric acid, H_2SO_4. Both of these can then precipitate from clouds as acid rain.

$$SO_2(g) + H_2O(l) \rightleftharpoons H_2SO_3(aq)$$

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

$$SO_3(g) + H_2O(l) \rightleftharpoons H_2SO_4(aq)$$

The other gaseous molecules are neutral and will not lead to the formation of acids.

Q3 **D** The **reductant** in a redox reaction **does the reducing**, therefore it **will lose electrons** as it **itself is oxidised**. Zinc is a good reductant and the half-equation showing zinc acting as a reductant is

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

Q4 **D** The vaporisation of water requires **separating the molecules from each other** as the water changes from a liquid to a gas. This requires breaking the weak bonds between the molecules, intermolecular forces. In water there is a **significant degree of hydrogen bonding between the water molecules** and the **energy required to break these is the main factor for the relatively high heat of vaporisation of water**.

Q5 **C** The total pressure of the gas when the tap between the two flaks is opened is the sum of the partial pressures of the gases. Boyles law can be used to calculate the partial pressures of the individual gas samples since the temperature is constant.

$P_1V_1 = P_2V_2$ therefore $P_2 = \dfrac{P_1V_1}{V_2}$

V_2 in each case will be the total volume when the tap is opened.

$V_2 = 1.00 + 2.00 = 3.00$ L

Sample in 1.00 L flask: $P_a = \dfrac{300 \times 1.00}{3.00} = 100$ kPa

Sample in 2.00 L flask: $P_b = \dfrac{150 \times 2.00}{3.00} = 100$ kPa

$P = P_a + P_b = 100 + 100 =$ **200 kPa**.

Q6 **C** M(NaCl)= 23.0 + 35.5 = 58.5 g mol^{-1}

n(NaCl) = m / M = 2.158 / 58.5 = 3.69×10^{-2} mol

c(NaCl) = n / V = 3.69×10^{-2} / (120/1000) = **0.307 M**

Q7 **C** Since the fuel is being made from **algae**, this can be **grown repeatedly** given the correct nutrients and therefore is a **renewable resource**.

Q8 **A** The chemical equation for the reaction is

$$2CH_3OH(g) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$$

Since the temperature and pressure are the same the volume ratio is the same as the stoichiometric ratio.
2 mol of CO_2 is produced when 3 mol of O_2 react.
$n(O_2) = {}^3/_2\ n(CO_2)$
$V(O_2) = {}^3/_2\ V(CO_2) = {}^3/_2 \times 5.6 =$ **8.4 L**

Q9 **C** $2Cu(NO_3)_2(s) \rightarrow 2CuO(s) + 4NO_2(g) + O_2(g)$

$M(Cu(NO_3)_2) = 63.6 + 2\times14.0 + 6\times16.0 = 187.6$ g
$M(CuO) = 63.6 + 16.0 = 79.6$ g mol^{-1}
$n(Cu(NO_3)_2) = m / M = 18.76/187.6 = 0.1000$ mol
$n(CuO) = n(Cu(NO_3)_2) = 0.1000$ mol
$m(CuO) = n \times M = 0.1000 \times 79.6 =$ **7.96 g**

Q10 **D** Plants in general cannot absorb nitrogen from the atmosphere. The legumes, and some other plants, can get their nitrogen indirectly from the atmosphere because they have Rhizobium nodules on their roots that can fix atmospheric nitrogen.

Q11 **A** When an ionic compound, such as sodium chloride, dissolves in water it dissociates into its ions, and it is these that carry the current in aqueous solutions, not electrons as is the case for electrical conductivity of metals.

$$NaCl(s) \xrightarrow{H_2O(l)} Na^+(aq) + Cl^-(aq)$$

Q12 **C** The pH of the solution is 12, therefore
$[H_3O^+] = 10^{-pH} = 10^{-12}$ M
The self ionisation constant for water at 25 ºC
$K_w = [H_3O^+][OH^-] = 10^{-14}$ M^2

$$[OH^-] = \frac{10^{-14}}{[H_3O^+]} = \frac{10^{-14}}{10^{-12}} = \mathbf{10^{-2}\ M}$$

Q13 **B** From the electrochemical series, Table 2 VCE Chemistry Data booklet the appropriate half-equations are

$$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s) \qquad E^o = -0.44\ V$$

$$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s) \qquad E^o = -0.76\ V$$

The **Fe^{2+} ion is the stronger oxidant therefore it will be reduced** while the Zn is oxidised to Zn^{2+}.

Q14 **B** The heat capacity of a substance is the amount of energy required to increase the temperature of the substance by 1 ºC (or 1 K) without changing the state of the substance. The heat capacity for water is 4.18 J g^{-1} K^{-1}.

Q15 **C** If the artefact is buried in the thick mud the amount of oxygen reaching it may be low and as a result the rate of corrosion would be slow. The mud layers on the bottoms of many lakes and waterways can tend to be significantly anaerobic. Therefore these can tend to preserve iron artefacts for longer than would normally be expected. Once the object is removed from the mud it may undergo rapid corrosion unless it is preserved. The oxidant responsible for corrosion is oxygen, and the rate is increased by the presence of impurities in the metal and ions in the aqueous environment.

Q16 **C** Copper(II) ions, Cu^{2+}, will form a precipitate when mixed with carbonates, as most carbonates, other than those of the Group I elements and ammonium, are insoluble. All common nitrate compounds are soluble and so too are most chloride compounds, except those of silver, mercury(II) and lead.

Q17 **D** Since metal Z reacted with both X^{2+} and Y^{2+} ions, therefore Z will be the strongest reductant. Metal X reacted with Y^{2+} ions therefore it will be a stronger reductant than Y. Therefore the order from weakest to strongest reductant will be **Y, X, Z**.

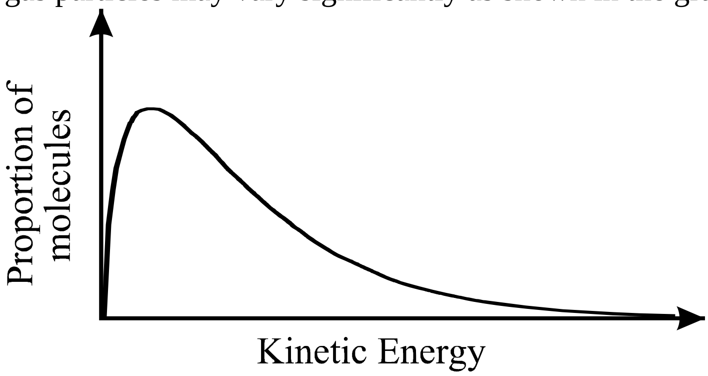
Q18 **B** n(NaOH) = c × V = 0.10 × (250/1000) = 0.025 mol
n(KOH) = c × V = 0.050 × (500/1000) = 0.025 mol
n(OH^-) = n(NaOH) + n(KOH) = 0.025 + 0.025 = 0.050 mol
V(total) = 250 + 500 = 750 mL
c(OH^-) = n / V = 0.050 / (750/1000) = **0.067 M**

Q19 **A** The chemical equation for the reaction is

$$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

M($CaCO_3$) = 40.1 + 12.0 + 3×16.0 = 100.1 g mol^{-1}
n($CaCO_3$) = m / M = 2.894 / 100.1 = 2.891×10^{-2} mol
n(HNO_3) = c × V = 0.100 × (500.0/1000) = 5.00×10^{-2} mol
From the chemical equation for this reaction the molar ratio of $CaCO_3$:HNO_3 is 1:2.
Therefore 5.00×10^{-2} mole of HNO_3 will react with 2.50×10^{-2} mole of $CaCO_3$.
Therefore based on this the $CaCO_3$ will be in excess
n($CaCO_3$, excess) = $2.891 \times 10^{-2} - 2.50 \times 10^{-2}$ = **3.91×10^{-3} mol**

Q20 **B** The kinetic molecular theory model states that average kinetic energy of a gas is related to the temperature of the gas. Within the sample the kinetic energies of the gas particles may vary significantly as shown in the graph.



Q21 **D** Ammonium nitrate, NH_4NO_3, is an ionic compound and the ions will interact with water molecules through ion-dipole interactions.

Q22 **A** **Hydrochloric acid is a strong acid** and will **completely ionise** in solution, therefore **[H_3O^+]** will be the same as the concentration of the acid, **0.10 M**.
Ethanoic acid is a weak acid and only **partially ionises** in water, therefore the **[H_3O^+] will be less than the acid concentration**.
Since pH = $-\log_{10}[H_3O^+]$ then the **pH of the hydrochloric acid will be lower** than that for the ethanoic acid. The pH for the 0.10 M aqueous solutions of hydrochloric and ethanoic acids, in this question, are 1.0 and 2.9 respectively.

Q23 **B** The **difference between the formulae for a conjugate acid/base pair is H^+**.
The conjugate base for the NH_4^+ ion will have a H^+ ion removed, therefore **NH_3**.

$$\underset{\text{acid 1}}{NH_4^+(aq)} + \underset{\text{base 2}}{H_2O(l)} \rightleftharpoons \underset{\text{base 1}}{NH_3(aq)} + \underset{\text{acid 2}}{H_3O^+(aq)}$$

Q24 **D** An ideal gas obeys Charles Law
V = kT where k is a constant for a given sample of gas at constant pressure and T is the temperature in Kelvin (K).
This gives a liner relationship between volume and temperature.
Assuming these ideal conditions, then at 0 K the volume will be zero.

Short Answer (Answers) – Section B

Question 1 (11 marks, 13 minutes)

a. The half-equations from the electrochemical series (Table 2 VCE Chemistry Data booklet)

$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$ $E^o = +0.34$ V

$Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$ $E^o = -0.13$ V

$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$ $E^o = -0.44$ V

From this data the Cu^{2+} ion is the strongest oxidant and the Fe is the strongest reductant.

In redox reactions the stronger oxidant is reduced while the stronger reductant is oxidised.

	Z^{2+}/Z half-cell	
	Cu^{2+}/Cu	Fe^{2+}/Fe
Type of half-reaction occurring at the Pb electrode.	**Oxidation** **The Pb is the stronger reductant and will be oxidised. (½ mark)**	**Reduction** **The Fe is the stronger reductant therefore reduction will occur at the Pb electrode. (½ mark)**
Oxidant	**Cu^{2+}(aq) (½ mark)**	**Pb^{2+}(aq) (½ mark)**
Reductant	**Pb(s) (½ mark)**	**Fe(s) (½ mark)**
Half-equation for the reaction occurring at the Z electrode.	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ **(½ mark)**	$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$ **(½ mark)**
Overall chemical equation for the reaction occurring in the cell.	$Cu^{2+}(aq) + Pb(s) \rightarrow Cu(s) + Pb^{2+}(aq)$ **(1 mark)**	$Pb^{2+}(aq) + Fe(s) \rightarrow Pb(s) + Fe^{2+}(aq)$ **(1 mark)**

b. i. The oxidant in both stages of the rusting process is **oxygen**. **(1 mark)**

ii. The reductant is **iron**. **(1 mark)**

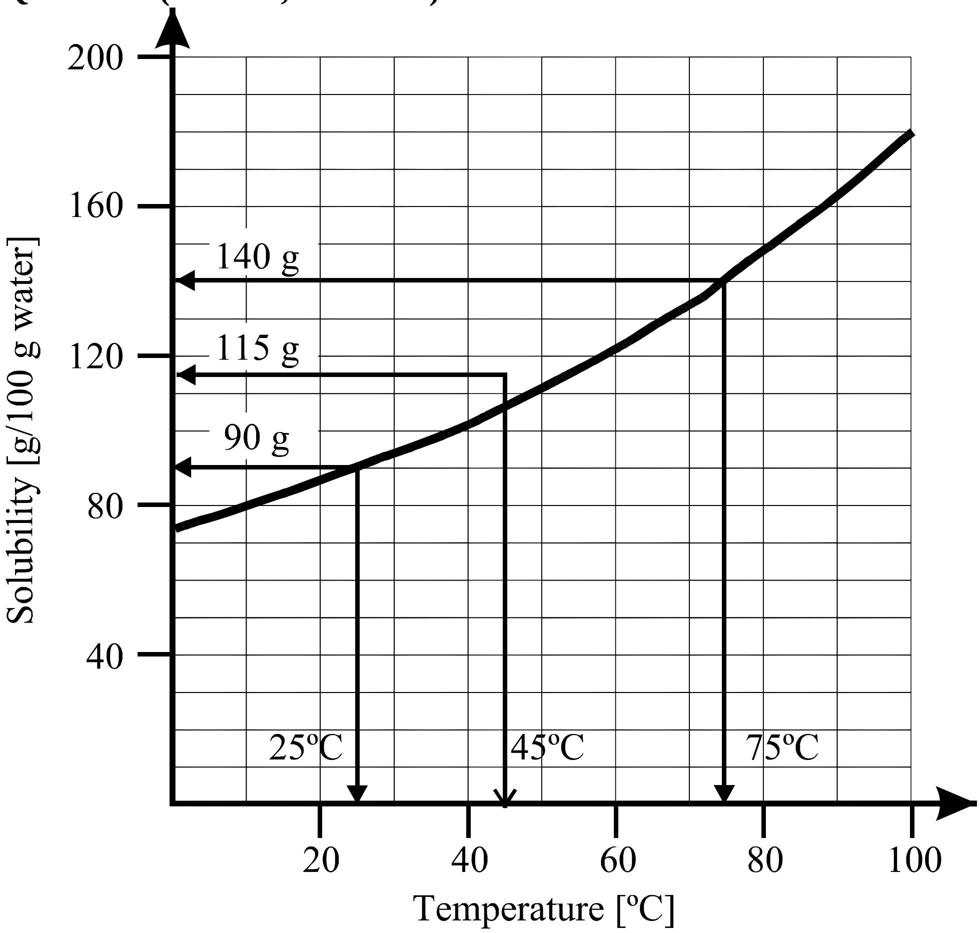
iii. $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$ **(1 mark)**

iv. $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$ **(1 mark)**

v. The **iron(II) ions, Fe^{2+}, and the hydroxide ions, OH^-**, combine to form the insoluble **iron(II) hydroxide, $Fe(OH)_2$**. **(1 mark)** The overall reaction that occurs during the first stage can be represented by the chemical equation

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

Question 2 (7 marks, 9 minutes)



Solubilities are expressed as mass of solute dissolved in 100 g of solute. Assuming the density of water is 1.0 g mL^{-1}, then 100 g = 100 mL.

a. 350 g of solute dissolved in 250 mL would require a solubility of
(350/250) × 100 = 140 g / 100 mL (**1 mark)**
From the solubility curve above this would require a minimum temperature of
75 ºC. (1 mark)

b. The solubility of sodium nitrate at 25 ºC is 90 g / 100 mL
To prepare a 1.00 L = 1000 mL saturated solution.
$m(NaNO_3)$ = 90 × (1000/100) = 900 g **(1 mark)**
$M(NaNO_3)$ = 23.0 + 14.0 + 3×16.0 = 85.0 g mol^{-1}
$n(NaNO_3)$ = m / M = 900 / 85.0 = 10.6 mol **(1 mark)**
$n(Na^+)$ = $n(NaNO_3)$ = 10.6 mol
$N(Na^+) = n \times N_A = 10.6 \times 6.02\times10^{23}$ = **6.38×10^{24} ions (1 mark)**

c. 23.0 g of solute dissolved in 20.0 mL would be equal to a solubility of
(23.0 / 20.0) × 100 = 115 g / 100 mL
At 45 ºC this is higher than the solubility for sodium nitrate, 105 g / 100 mL, therefore the solution is **supersaturated**. **(1 mark)**
Adding a few crystals to a supersaturated solution should seed the solution and **crystals of sodium nitrate should be seen to form in the solution**. **(1 mark)**

Question 3 (8 marks, 10 minutes)

a. i. Flocculation involves **adding alum**, potassium aluminium sulfate, $KAl(SO_4)_2.12H_2O$, to the water and lime, calcium hydroxide, $Ca(OH)_2$, if the water is slightly acidic. **(1 mark)** This process causes any **insoluble small particles** in the water **to join together to form larger particles that will sink from and settle out of the water**. **(1 mark)**

ii. Water supplies are **chlorinated to kill or destroy bacteria** that could be harmful to humans. **(1 mark)**

b. i. **'Hard' water is due to the presence** of either **calcium, Ca^{2+}, magnesium, Mg^{2+}, or iron(II), Fe^{2+}, ions dissolved in the water**. **(1 mark)**

ii. When **soaps** are used with 'hard' water they **form an insoluble scum** and **do not produce a satisfactory lather**. **(1 mark)**

c. i. **Desalination** involves the **removal of sodium chloride**, salt, from **sea water or brackish water**. **(1 mark)**

ii. Three possible answers. **(Mark allocation 1 mark for correct response]**

Distillation
Reverse osmosis
Ion Exchange

iii. Answer depends on ii. above. **(Mark allocation 1 mark for correct response]**

Distillation - The original water sample is boiled and the water vapour is condensed to produce the desalinated water.

Reverse osmosis - Water molecules are forced under pressure through a membrane that does not allow dissolved ions to pass through it.

Ion exchange - The water is passed through two beds of ion exchange resins. In one any dissolved cations are replaced by H^+ ions, and in the other any dissolved anions are replaced by OH^- ions.

Question 4 (11 marks, 13 minutes)

a. Either full or ionic equations would be acceptable.

i. $Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$, or

$Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$ **(1 mark)**

ii. $CH_3COOH(aq) + NaHCO_3(s) \rightarrow NaCH_3COO(aq) + CO_2(g) + H_2O(l)$, or

$H^+(aq) + NaHCO_3(s) \rightarrow Na^+(aq) + CO_2(g) + H_2O(l)$ **(1 mark)**

iii. $Ba(OH)_2(aq) + 2HNO_3(aq) \rightarrow Ba(NO_3)_2(aq) + 2H_2O(l)$, or

$OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$ **(1 mark)**

iv. $HSO_4^-(aq) + H_2O(l) \rightleftharpoons H_2SO_4(aq) + OH^-(aq)$ **(1 mark)**

b. i. n(HCl) = c × V = 0.100 × (23.56/1000) = **2.36×10^{-3} mol. (1 mark)**

ii. From the chemical equation the stoichiometry for this reaction is $n(NH_3) = n(HCl)$ = **2.36×10^{-3} mol. (1 mark)**

iii. The original 10.00 mL sample was diluted to 100.00 mL and 20.00 mL samples were analysed.

$n(NH_3$, original sample) = $n(NH_3$, in 100 mL of diluted sample)

$n(NH_3$, original sample) = 2.36×10^{-3} × (100.00/20.00) **= 1.18×10^{-2} mol (1 mark)**

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

$m(NH_3) = n \times M = 1.18\times10^{-2} \times 17.0$ = **0.201 g (1 mark)**

c. i. $M(NaOH) = 23.0 + 16.0 + 1.0 = 40.0\ g\ mol^{-1}$
$n(NaOH) = m / M = 0.200 / 40.0 = 5.00\times10^{-3}$ mol
$c(NaOH) = n / V = 5.00\times10^{-3} / (500/1000) =$ **0.0100 M (1 mark)**

ii. The self ionisation constant for water given in Table 3 VCE Chemistry Data booklet
$K_w = [H_3O^+][OH^-] = 1.00\times10^{-14}\ M^2$ at 25 ºC
$[H_3O^+] = \frac{10^{-14}}{[OH^-]} = \frac{10^{-14}}{0.0100} = 1.00\times10^{-12}$ M **(1 mark)**
$pH = -\log_{10}[H_3O^+] = -\log_{10}(1.00\times10^{-12}) =$ **12.0 (1 mark)**

Question 5 (7 marks, 9 minutes)

a. i. $n(H_2O_2) = c \times V = 1.80 \times (600.0/1000) = 1.08$ mol **(1 mark)**
From the chemical equation;
$n(O_2) = ½\ n(H_2O_2) = ½ \times 1.08 = 0.540$ mol
Since the conditions are SLC then the molar volume, V_m, can be used.
$V(O_2) = n \times V_m = 0.540 \times 24.5 =$ **13.2 L (1 mark)**

ii. Placing a **glowing splint** into oxygen gas will cause **the splint to reignite** and burn vigorously. **(1 mark)**

b. i. Since the conditions are not standard, then the general gas equation is required
PV = nRT
The required units are kPa, L and K for pressure, volume and temperature respectively.
$n = \frac{PV}{RT} = \frac{155 \times 0.756}{8.31 \times (24.6 + 273)}$ = **4.74×10^{-2} mol (1 mark)**

ii. $M = m / n = 2.180 / 4.74\times10^{-2} =$ **$46.0\ g\ mol^{-1}$ (1 mark)**

c. i. The two main pollutants that cause photochemical smog are **unburnt hydrocarbons** and **nitrogen oxides (NO_x, NO, or NO_2). (1 mark)**

ii. The main source of these pollutants is **vehicle internal combustion engines**. **(1 mark)**

Question 6 (6 marks, 7 minutes)

a. Atom economy refers to the **number of atoms in the reactants that are present in the desired product**. **(1 mark)** In green chemistry the ideal is to maximise this so that as many as possible of the reactant atoms are in the product.

b. **Preventing** the formation of **waste reduces the need to treat the waste or to clean it up after it is formed**. **(1 mark)** Many processes have been and are still used that produce toxic materials as waste, the storage, treatment and disposal of these can be costly and can be harmful to the environment.

c. i. **Supercritical carbon dioxide. (1 mark)** Supercritical carbon dioxide has been successfully used to replace chlorinated hydrocarbons in dry cleaning and solvent extraction processes. The carbon dioxide does not leave a solvent residue that is toxic.

ii. Chlorinated hydrocarbons are toxic and harmful to health and the environment. **(1 mark)**

d. i. If the product is designed to degrade and break down into harmless substances after its lifetime then **it will not build up in the environment**. **(1 mark)**
Non-degradable plastic bags are causing a major environmental problem as they can enter waterways and then into the oceans where they are having a significant impact on marine life in some areas. It has been reported that there is a large area in the Pacific Ocean that is laden with this type of waste.

ii. If it is not degradable then ideally it should be able to be **recycled or reused**. **(1 mark)**

End of Suggested Answers