VCE CHEMISTRY 2014

YEAR 11 TRIAL EXAM

Unit 2
Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	8	8	52
			Total 72

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http://www.vcaa.vic.edu.au/Documents/exams/chemistry/chemdata_2012-w.pdf

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STUDENT NUMBER

									Letter
Figures									
Words									

Student Name.....…….....

VCE Chemistry 2014 Year 11 Trial Exam Unit 2

Student Answer Sheet

Instructions for completing test. Use only a 2B pencil. If you make a mistake erase, it 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 **20 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

VCE Chemistry 2014 Year 11 Trial Exam Unit 2

SECTION A – Multiple Choice Questions

(20 marks, 25 minutes)

This section contains 20 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 technique that could be used to produce a sample of desalinated water is
A. evaporation.
B. boiling.
C. distillation.
D. precipitation.

Question 2
The concentration of hydroxide ions in a 0.0010 M aqueous solution of a strong acid would be closest to
A. 1.0×10^{-3} M.
B. 1.0×10^{-11} M.
C. 0 M.
D. 1.0×10^{-17} M.

Question 3
The concentration of nitrate ions in an aqueous solution prepared by dissolving 5.00 g of solid hydrated copper(II) nitrate, $Cu(NO_3)_2\cdot6H_2O$ ($M = 295.5$ g mol^{-1}), in 250 mL of deionised water would be
A. 0.135 M.
B. 0.107 M.
C. 0.213 M.
D. 0.0677 M.

Question 4
Copper metal can be produced by smelting copper(I) sulfide, Cu_2S. This smelting reaction can be represented by the chemical equation;

$$Cu_2S(s) + O_2(g) \rightarrow 2Cu(s) + SO_2(g)$$

The mass of copper(I) sulfide required to produce 1.00 t (1 t = 1000 kg) of copper metal would be
A. 2.50 t.
B. 1.25 t.
C. 5.01 t.
D. 0.80 t.

Question 5
When aqueous solutions of lead(II) nitrate and potassium iodide are mixed,
A. a white precipitate of potassium nitrate will form.
B. no precipitate will form.
C. a yellow precipitate of lead(II) iodide will form.
D. a brown solution containing iodine will be formed.

Question 6
The volume of 0.120 M aqueous hydrochloric acid solution required to neutralise a 25.00 mL aliquot of 0.0500 M aqueous sodium hydrogen carbonate solution will be
A. 41.6 mL.
B. 30.0 mL.
C. 20.8 mL.
D. 10.4 mL.

Question 7
In an aqueous solution of a weak acid, the concentration of the
A. hydrogen ions will be greater than the concentration of the ionised acid.
B. unionised acid will be greater than the concentration of the ionised acid.
C. ionised acid will be greater than the concentration of the unionised acid.
D. unionised acid will be about the same as the concentration of the ionised acid.

Question 8
In the reduction-oxidation, redox, reaction between copper metal and silver ions, the
A. silver ions will be reduced receiving electrons from the copper.
B. copper will be oxidised receiving electrons from the silver ions.
C. silver ions will be oxidised transferring electrons to the copper.
D. silver ions will be reduced transferring electrons to the copper.

Question 9
The complete combustion of propane at 400 K can be represented by the chemical equation;

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

A stoichiometric mixture of propane and oxygen was placed in a piston that exerted a constant pressure while maintaining a constant temperature of 400 K and ignited. Compared to the original volume of the gas mixture, V, the volume of the product mixture would be
A. $^6/_7$ V.
B. $^3/_6$ V.
C. $^7/_5$ V.
D. $^7/_6$ V.

Question 10
The main effect of gases that contribute to the enhanced greenhouse effect is that they
A. absorb ultraviolet light from the Sun's light.
B. allow more infra red light from the Sun's light to reach the Earth's surface.
C. absorb infrared light emitted from the Earth's surface.
D. allow ultraviolet light emitted from the Earth's surface to pass through.

Question 11
The level of nitrogen in the upper layer of soil on a farm would be decreased by
A. the addition of ammonium based fertilizers.
B. animals excreting waste.
C. the action of lightning in the atmosphere.
D. heavy rainfall draining into the groundwater.

Question 12
The thermal decomposition of cobalt(II) nitrate can be represented by the chemical equation;

$$2Co(NO_3)_2(s) \rightarrow 2CoO(s) + 4NO_2(g) + O_2(g)$$

A student heated a sample of cobalt(II) nitrate in a test tube until no further gases were given off. The mass of solid remaining in the test tube was found to be 3.201 g. The volume of nitrogen(IV) oxide gas, $NO_2(g)$, that would have been formed at SLC would be
A. 1.92 L.
B. 2.09 L.
C. 1.05 L.
D. 0.89 L.

Question 13
According to the kinetic molecular theory model for gases,
A. all the particles in a sample of gas have the same kinetic energy which mainly depends on the temperature of the gas.
B. the average kinetic energy of the particles in a sample of gas depends equally on the molar mass, pressure and temperature of the gas.
C. all the particles in a sample of gas have the same kinetic energy which depends equally on the molar mass, pressure and temperature of the gas.
D. the average kinetic energy of the particles in a sample of gas depends mainly on the temperature of the gas.

Question 14
Human activity has resulted in a decrease in the levels of
A. nitrogen oxides in the lower atmosphere.
B. ozone in the stratosphere.
C. chlorine in the stratosphere.
D. ozone in the lower atmosphere.

Question 15
A 0.01 mole sample of argon gas was placed in a piston and occupied a volume of 120 mL when a pressure of 200 kPa was exerted on it. When a 0.01 mole sample of neon was placed in the same piston at the same temperature and a pressure of 300 kPa was applied, the volume occupied by the gas would be

A. 160 mL.
B. 320 mL.
C. 80 mL.
D. 120 mL.

Question 16
When students place a sample of tin metal in an aqueous solution of zinc sulfate they should observe

A. a gas being given off.
B. no reaction occurring.
C. the formation of a precipitate.
D. a plating of zinc metal forming on the surface of the tin.

Question 17
When an ionic compound dissolves in water, the ions will form

A. ion-dipole bonds with the water molecules.
B. hydrogen bonds with the water molecules.
C. dipole-dipole bonds with the water molecules.
D. ionic bonds with the water molecules.

Question 18
When an aqueous solution of an acid reacts with an aqueous solution of lithium hydroxide, the pH will

A. decrease and a gas will be formed.
B. increase and a precipitate will be formed.
C. decrease and a clear solution will be formed.
D. increase and a gas will be formed.

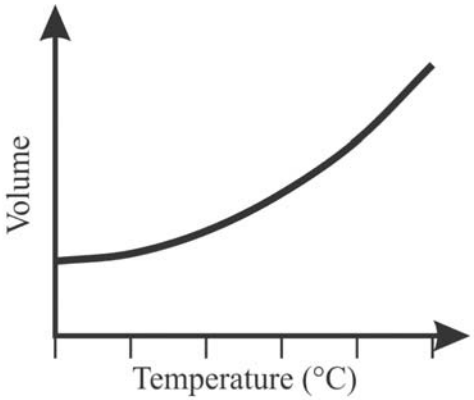
Question 19
The gases that mainly contribute to the formation of photochemical smog are

A. nitrogen, unburnt hydrocarbons and oxygen.
B. nitrogen oxides, unburnt hydrocarbons and oxygen.
C. nitrogen oxides and oxygen.
D. unburnt hydrocarbons and nitrogen.

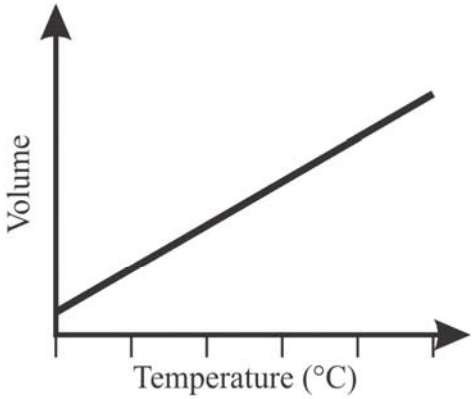
Question 20

The graph that would best describe how the volume of an ideal gas sample would behave between 0 °C and 500 ° would be

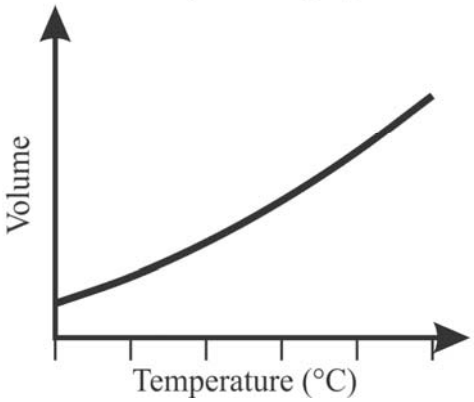
A.



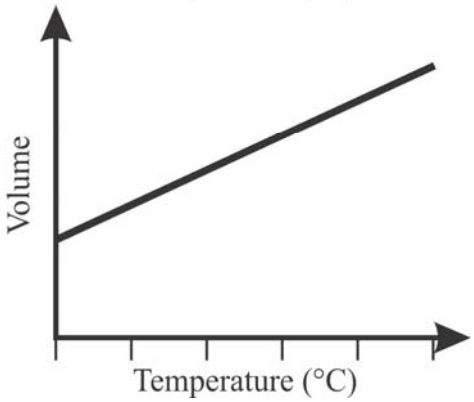
B.



C.



D.



End of Section A

VCE Chemistry 2014 Year 11 Trial Exam Unit 2

SECTION B – Short Answer Questions

(52 marks, 65 minutes)

This section contains eight questions, numbered 1 to 8.
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 (6 marks, 7 minutes)

a. Write an appropriate chemical equation to represent the reaction that would occur when an aqueous solution of hydrochloric acid is added to a sample of magnesium carbonate. **1 mark**

b. Calculate the stoichiometric volume of 0.50 M aqueous hydrochloric acid that would be required to completely react with 2.580 g sample of magnesium carbonate. **3 marks**

c. The mass of 200.0 mL of 0.50 M aqueous hydrochloric acid is 200.00 g. The mass of a clean dry flask was 35.06 g.
A new 2.580 g sample of magnesium carbonate was placed in the flask and the acid added to it and allowed to completely react.
Determine the mass of the flask and its contents at the completion of the reaction. **2 marks**

Question 2 (10 marks, 13 minutes)

a. Hydrochloric acid is a strong acid.

i. Calculate the pH of an aqueous 0.050 M solution of hydrochloric acid. **1 mark**

ii. Calculate the concentration of the hydroxide ion in a 100.0 mL sample of this solution at 25 C°. **1 mark**

b. Nitrous acid, HNO_2, is a weak acid.

i. Write an appropriate chemical equation for the ionisation of this acid in water. **1 mark**

ii. How would the pH of an aqueous 0.050 M solution of nitrous acid compare with the pH of the aqueous 0.050 M hydrochloric acid solution calculated in **a. i.** above. **1 mark**

c. The carbonate ion, $CO_3^{2-}(aq)$, is a base. Write an appropriate chemical equation to show the formation of the conjugate acid in aqueous solution. **1 mark**

d. The label on an oven cleaner stated that the active ingredient in the product was sodium hydroxide, NaOH (M = 40.0 g mol^{-1}). The laboratory report from a group of VCE chemistry students who analysed a sample of this product is shown below.

It was assumed that the only base in the product was the active ingredient. A 4.156 g sample of the product was placed in a volumetric flask, diluted with deionised water so that the total volume of solution was 250.0 mL and thoroughly mixed. 20.00 mL aliquots of this solution were titrated with an aqueous 0.0150 M sulfuric acid solution. The average titre volume was 14.6 mL.

The chemical equation for the reaction between sulfuric acid and sodium hydroxide can be represented by

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

i. Calculate the amount of sulfuric acid in the average titre. **1 mark**

ii. Calculate the amount of sodium hydroxide in the aliquot. **1 mark**

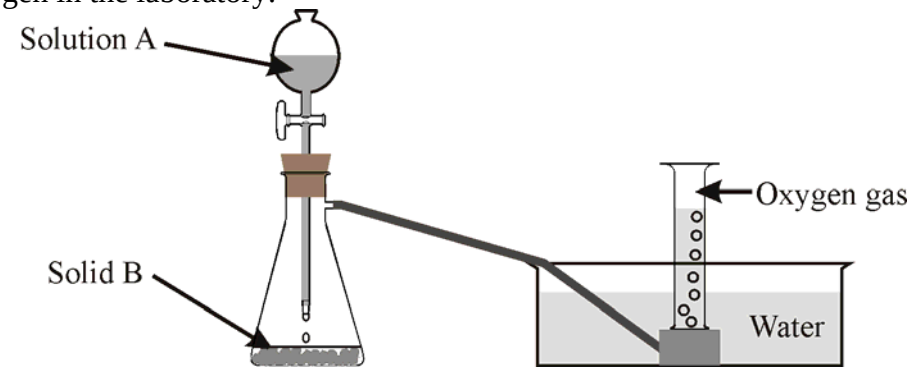
iii. Calculate the mass of sodium hydroxide in the sample. **2 marks**

iv. Calculate the mass of sodium hydroxide in 1.00 kg of the product. **1 mark**

Question 3 (7 marks, 9 minutes)

a. Explain two different ways in which carbon can be removed from the atmosphere. **2 marks**

b. The diagram below shows the apparatus that can be used to prepare a sample of oxygen in the laboratory.



What are the reagents commonly used to prepare oxygen in the laboratory? **2 marks**

Solution A:

Solid B:

c. Describe how oxygen can be produced industrially. **1 mark**

d. In the following table **circle** the characteristic of oxygen relevant for each property. **2 marks**

Property			
Odour	Pungent smell	Odourless	Sweet smell
Solubility in water at 25 °C	Soluble	Insoluble	Slightly soluble
pH of an aqueous solution	Neutral	Basic	Acidic
Flammability	Does not support combustion	Flammable	Supports combustion

Question 4 (7 marks, 9 minutes)

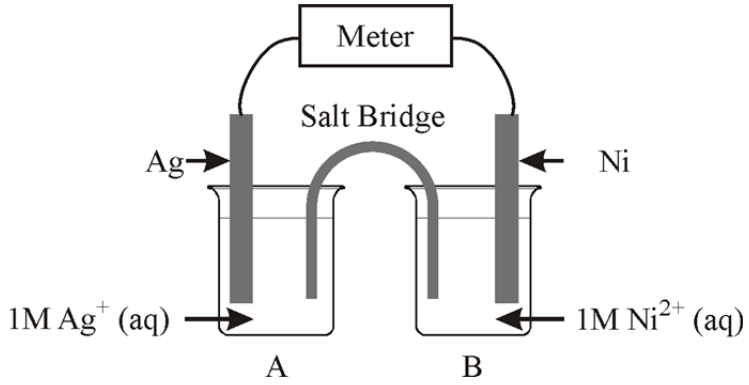
a. Determine the formal oxidation number for the chromium in the oxide with the chemical formula, Cr_2O_3. **1 mark**

b. Steel (iron) roofing sheets can be afforded corrosion protection by galvanising them with zinc metal.

i. Explain why the zinc would protect the steel from corrosion. **1 mark**

ii. Explain what would happen if a small section of the zinc coating were removed from the steel sheet, exposing it to the atmosphere. **1 mark**

c. The diagram below shows the apparatus that was set up to investigate the reaction between nickel metal and silver ions.



i. What chemical process would occur in half-cell A? **1 mark**

ii. Write an appropriate half-equation for the reaction that would occur in half-cell B. **1 mark**

iii. Write an appropriate chemical equation for the reaction between a piece of nickel metal and an aqueous solution of silver nitrate. **1 mark**

iv. Which way would the electrons flow through the external circuit? **1 mark**

Question 5 (6 marks, 7 minutes)

a. A 1.50 L reactor was filled with 4.28 g of ammonia gas, NH_3, at -15 °C. Determine the pressure exerted by the ammonia gas in the reactor. **2 marks**

b. The reaction between phosphorous and oxygen at SLC can be described by the chemical equation:

$$P_4(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$$

A 0.0050 mol sample of phosphorous was placed in a reaction vessel that contained 2.0 L of oxygen gas and allowed to react. The vessel was allowed to return to SLC following the reaction. Determine the volume of oxygen present in the vessel after the reaction. **2 marks**

c. A sample of gas was placed in a piston and occupied a volume of 0.58 L at 103 kPa and 18 °C. The conditions were altered so that the temperature and pressure were 48 kPa and 410 K. Determine the volume that the gas would occupy under these conditions. **2 marks**

Question 6 (4 marks, 5 minutes)

The practice of green chemistry is based on twelve principals defined by its proposers, which are summarised below.

1. Prevent waste.
2. Maximise atom economy.
3. Use less hazardous synthetic processes.
4. Design safer less toxic chemicals and products.
5. Minimise the use of chemical derivatives in the production process.
6. Increase the energy efficiency of the process.
7. Use renewable raw materials as a feedstock.
8. Use safer solvents and reaction conditions.
9. Use catalytic reactions where possible.
10. The products should be designed with their end-life in mind.
11. Real-time monitoring needs to be employed to monitor potential hazards and/or pollution.
12. Minimise the potential for chemical accidents, explosions and fires.

a. Explain two of these principles that would apply if a user switched from an herbicide produced from petroleum based products to one extracted from other widely available plant matter. **2 marks**

b. Explain how the use of catalysts in an industrial process could assist a chemical company in meeting two other principles of green chemistry. **2 marks**

Question 7 (5 marks, 6 minutes)

a. When aqueous solutions of sodium hydroxide and zinc(II) sulfate are mixed, a white precipitate is formed. Write an appropriate chemical equation to describe the reaction that occurs. **1 mark**

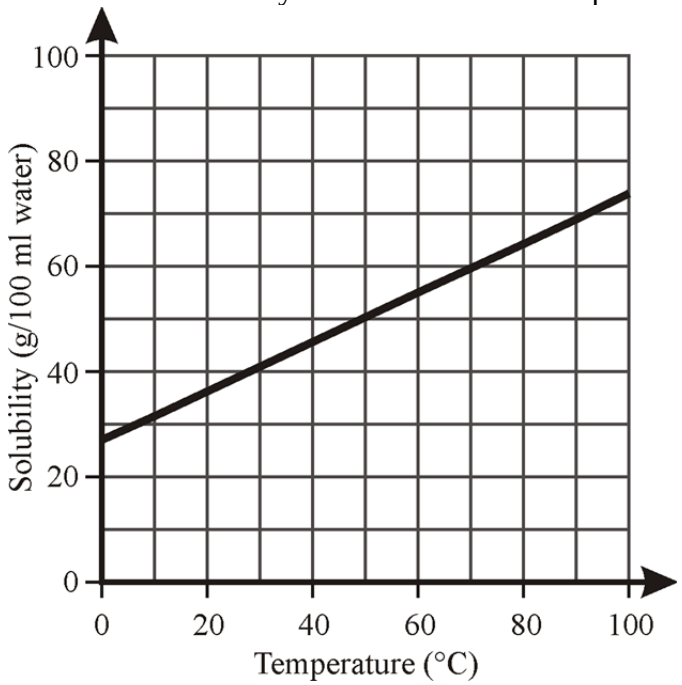
b. Large volumes of water are used in the cooling towers associated with the power plants in the Latrobe Valley. What property of water does the process occurring in the cooling towers rely on? **1 mark**

c. Draw a diagram to show how water molecules would interact with ammonia molecules in an aqueous solution of ammonia. State the strongest type of interaction that would occur between the water and ammonia molecules. **2 marks**

d. Describe how the solubility of a gas, such as carbon dioxide, in an aqueous solution would change with increasing temperature. **1 mark**

Question 8 (7 marks, 9 minutes)

a. The graph below shows the solubility curve for an ionic compound.



25.0 g of solid was added to a beaker containing 50 mL of water. The mixture was heated to 80 °C at which temperature there was no solid remaining in the mixture.

i. The solution was cooled to 65 °C and held at this temperature for a period. No solid was observed to crystallize from the solution during this time. Determine if the solution at this temperature was saturated, unsaturated or super saturated. **1 mark**

ii. The solution was then allowed to cool to 25 °C overnight during which time crystals formed in the beaker. Determine the mass of crystals that would be expected to form in the beaker. **1 mark**

b. The complete combustion of methane, CH_4 (M = 16.0 g mol^{-1}), can be described by the chemical equation:

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

i. Determine the volume of oxygen required at SLC to completely burn 1.00 kg of methane. **1 mark**

ii. Determine the volume of carbon dioxide at SLC that would be produced in this reaction. **1 mark**

iii. Determine the volume of liquid water that would be produced (density of water at 25 °C = 1.00 g mL^{-1}). **1 mark**

c. Explain following observations regarding gases using the kinetic theory model.

i. The pressure of a gas inside a rigid container increases when it is heated. **1 mark**

ii. Winds in the atmosphere always blow from areas of high pressure to areas of low pressure. **1 mark**

End of Section B

End of Trial Exam

Suggested Answers

VCE Chemistry 2014 Year 11 Trial Exam Unit 2

SECTION A – Multiple Choice Answers

(1 mark per question)

Q1 **C** Desalination involves the production of water from salt or sea water. There are a number of methods for desalinating water, however the only method listed in the responses that could achieve this would be distillation.
Distillation involves boiling the impure or salty water to form water vapour, then condensing this water vapour to form liquid water. This was the traditional method used in laboratories to produce pure water for preparing aqueous solutions of reagents. This method consumes large amounts of energy to produce the water vapour. Ion exchange is now the more favoured method in laboratories.
Large scale desalination, as at the Wonthaggi desalination plant, uses the less energy intensive method of reverse osmosis.

Q2 **B** A strong acid will completely ionise in solution.
Therefore $[H_3O^+] = 0.0010 = 1.0\times10^{-3}$ M.
The self ionisation constant for water at 25 °C (VCE Chemistry Data Book: Table 3) $K_w[H_3O^+][OH^-] = 1.0\times10^{-14}$ M^2.
$[OH^-] = 1.0\times10^{-14} / 1.0\times10^{-3} =$ **1.0×10^{-11} M**.

Q3 **A** $n(Cu(NO_3)_2\cdot6H_2O) = m/M = 5.00 / 295.5 = 1.69\times10^{-2}$ mol
$n(NO_3^-) = 2\times n(Cu(NO_3)_2\cdot6H_2O) = 2 \times 1.69\times10^{-2} = 3.38\times10^{-2}$ mol
$c(NO_3^-) = n/V = 3.38\times10^{-2} / (250.0/1000) =$ **0.135 M**

Q4 **B** The chemical equation for the reaction:

$$Cu_2S(s) + O_2(g) \rightarrow 2Cu(s) + SO_2(g)$$

$m(Cu) = 1.00$ t $= 1000.0$ kg $= 1.00\times10^6$ g
$n(Cu) = m/M = 1.00\times10^6 / 63.5 = 1.57\times10^4$ mol
$n(Cu_2S) = ½n(Cu) = ½ \times 1.57\times10^4 = 7.85\times10^3$ mol
$m(Cu_2S) = 2\times63.5 + 32.1 = 159.1$ g mol^{-1}
$m(Cu_2S) = n\times M = 7.85\times10^3 \times 159.1 = 1.25\times10^6$ g = **1.25 t**

Q5 **C** The reaction is between lead(II) nitrate and potassium iodide. All common potassium and nitrate compounds are soluble. Lead iodide, PbI_2, is insoluble and the reaction can be described by the ionic chemical equation:

$$Pb^{2+}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$$

Lead(II) iodide is bright yellow in colour and this reaction is often used to visually demonstrate the formation of a precipitate since the two reacting solutions are colourless.

Q6 **D** The reaction between acids, $H^+(aq)$, and hydrogen carbonates, $HCO_3^-(aq)$, produces carbon dioxide and water.
The reaction between aqueous solutions of hydrochloric acid and sodium hydrogen carbonate can be described by the chemical equation:
$HCl(aq) + NaHCO_3(aq) \rightarrow NaCl(aq) + CO_2(g) + H_2O(l)$
$n(NaHCO_3) = c \times V = 0.0500 \times (25.00/1000) = 1.25 \times 10^{-3}$ mol
$n(HCl) = n(NaHCO_3) = 1.25 \times 10^{-3}$ mol
$V(HCl) = n/c = 1.25 \times 10^{-3} / 0.12 = 1.04 \times 10^{-2}$ L = **10.4 mL**

Q7 **B** Weak acids, HA, only partially ionise when dissolved in water.
$HA(aq) + H_2O(l) \rightleftharpoons A^-(aq) + H_3O^+(aq)$
Therefore the concentration of the unionised acid will be greater than the concentration of the ionised acid.

Q8 **A** When a piece of copper metal is placed in an aqueous solution of silver nitrate, a redox reaction occurs. In this reaction the **silver ions are reduced** and the **copper is oxidised**, therefore **electrons are transferred from the copper metal to the silver ions**.
The appropriate half-equations can be obtained from the Electrochemical Series (Table 2: VCE Chemistry Data Book).
Reduction: $Ag^+(aq) + e^- \rightarrow Ag(s)$
Oxidation: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$
Overall: $2Ag^+(aq) + Cu(s) \rightarrow 2Ag(s) + Cu^{2+}(aq)$

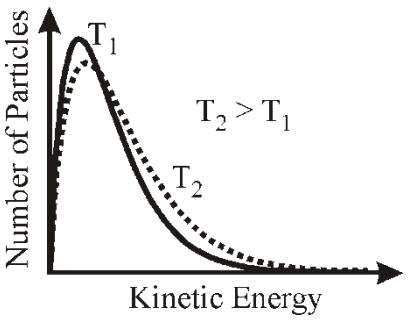
Q9 **D** The conditions, temperature and pressure, are kept constant, therefore the volume ratio can be used to carry out calculations.
$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$
The total volume of reactants is V and this equates to 6 units.
The total number of products is 7 units.
Therefore the final volume will be $^{7}/_{6}\mathbf{V}$.

Q10 **C** The main effect that the gases contributing to the enhanced greenhouse effect have is that they absorb the infra red radiation emitted from the Earth's surface, thereby trapping heat in the atmosphere.

Q11 **D** Nitrogen in the soil is usually in the form of either the ammonium, NH_4^+, or nitrate, NO_3^-, ions. Ammonium and nitrate compounds are soluble in water, therefore heavy rains draining water into the groundwater will remove these ions from the upper layer of the soil.

Q12 **B** $m(CoO) = 3.201$ g $M(CoO) = 58.9 + 16.0 = 74.9$ g mol^{-1}
$2Co(NO_3)_2(s) \rightarrow 2CoO(s) + 4NO_2(g) + O_2(g)$
$n(CoO) = m/M = 3.201 / 74.9 = 4.27 \times 10^{-2}$ mol
$n(NO_2) = 2 \times n(CoO) = 2 \times 4.27 \times 10^{-2} = 8.55 \times 10^{-2}$ mol
At SLC $V_m = 24.5$ L mol^{-1} (Table 3: VCE Chemistry Data Book)
$V(NO_2) = n \times V_m = 8.55 \times 10^{-2} \times 24.5 =$ **2.09 L**

Q13 D Within a sample of gas, the particles have a range of kinetic energies. The average kinetic energy depends on the temperature of the gas sample.
Increasing the temperature of a gas increases the average kinetic energy of the particles and changes the distribution of the particle energies.



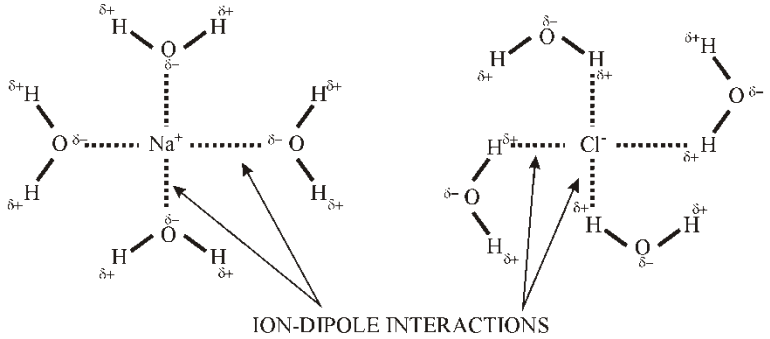
Q14 B Human activity has resulted in the depletion of ozone in the ozone layer which is in the stratosphere.
Pollution results in the formation of ozone in the lower atmosphere.

Q15 C Both argon and neon will behave as ideal gases. The same amounts of gas are present in the piston on both occasions.
Since the temperature is kept constant then the relationship can be applied:
$P_1V_1 = P_2V_2$

$$V_2 = \frac{P_1V_1}{P_2} = \frac{200 \times 120}{300} = \mathbf{80\ mL}$$

Q16 B Referring to the Electrochemical Series (Table 2: VCE Chemistry Data Book) or an activity series, tin is a weaker reductant than zinc, therefore **no reaction** would be expected to occur.

Q17 A **Water is pola**r, therefore the ions will form **ion-dipole bonds** with the water molecules.



Q18 C A solution of lithium hydroxide, a base, will have a pH greater than 7. As the acid is added to the solution, the hydrogen and hydroxide ions will react to form water. Therefore the **pH of the solution will decrease**.
Lithium is a Group 1 element and all common ionic compounds are soluble.
When the amount of acid added is the same as the initial amount of lithium hydroxide (the equivalence point), the pH will be 7. Adding more acid will make the solution acidic, therefore the pH will be less than 7.

Q19 B Photochemical smog is formed when unburnt hydrocarbons from vehicle emissions combine with nitrogen oxides and oxygen and undergo a photochemical reaction. Photochemical reactions are ones that are brought about by the action of light.

Q20 D The relationship between the volume of a gas and temperature is described by Charles' Law. The relationship is linear (straight line) with the temperature of the gas being required in Kelvin.
While the graph in Response B shows a linear relationship it would give a zero volume for the gas at a temperature in excess of 0 K (-273 °C).

SECTION B - Short Answer (Answers)

Question 1 (6 marks, 7 minutes)

a. Either a full or ionic equation would be appropriate **(1 mark)**.

$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$

$MgCO_3(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + CO_2(g) + H_2O(l)$

b. $M(MgCO_3) = 24.3 + 12.0 + 3\times16.0 = 84.3$ g mol^{-1}
$n(MgCO_3) = m/M = 2.580 / 84.3 = 3.06\times10^{-2}$ mol **(1 mark)**
$n(HCl) = 2\times n(MgCO_3) = 2 \times 3.06\times10^{-2} = 6.12\times10^{-2}$ mol **(1 mark)**
$V(HCl) = n/c = 6.12\times10^{-2} / 0.50 = 0.122$ L = **122 mL (1 mark)**

c. Since the carbon dioxide formed is a gas it can escape from the flask as this is open to the atmosphere.
From b. above:
$n(CO_2) = n(MgCO_3) = 3.06\times10^{-2}$ mol
$M(CO_2) = 12.0 + 2\times16.0 = 44.0$ g mol^{-1}.
$m(CO_2) = n\times M = 3.06\times10^{-2} \times 44.0 = 1.347$ g **(1 mark)**
Mass of flask and reactants = 35.06 + 200.00 + 2.580 = 237.64 g
Mass at end = 237.64 – 1.347 = **236.3 g (1 mark)**

Question 2 (10 marks, 13 minutes)

a. i. $[H^+] = 0.050$ M
$pH = -\log_{10}[H^+] = -\log_{10}(0.050) =$ **1.3 (1 mark)**

ii. The self ionisation constant of water at 25 °C: $K_w = 1.0\times10^{-14}$ M^{-2}
Table 3: VCE Chemistry Data Book
$(0.050)[OH^-] = 1.0\times10^{-14}$
$[OH^-] = 1.0\times10^{-14} / 0.050 =$ **2.0×10^{-13} M (1 mark)**

b. i. $HNO_2(aq) + H_2O(l) \rightleftharpoons NO_2^-(aq) + H_3O^+(aq)$ **(1 mark)**

ii. The concentrations of the two acids are the same, however because the **nitrous acid has only partially ionised** in solution, the pH of this solution will be **higher than 1.3 but less than 7 (1 mark)** (Actually about 2.2).

c. A base is a proton acceptor.
The difference between the formulae of a conjugate acid/base pair is H^+.
$CO_3^{2-}(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + OH^-(aq)$ **(1 mark)**
The hydrogen carbonate ion, HCO_3^-, is the conjugate acid of the carbonate ion.

d. i. $n(H_2SO_4) = c\times V = 0.015 \times(14.6/1000) =$ **2.19×10^{-4} mol (1 mark)**

ii. $H_2SO_4(aq) + 2NaOH \rightarrow Na_2SO_4(aq) + 2H_2O(l)$
The chemical equation for the neutralisation reaction has a H_2SO_4:NaOH ratio of 1:2.
$n(NaOH) = 2\times n(H_2SO_4) = 2 \times 2.19\times10^{-4} =$ **4.38×10^{-4} mol (1 mark)**

iii. All of the sodium hydroxide from the product was dissolved in the 250.0 mL.
$n(NaOH, total) = 4.38\times10^{-4} \times (250.0/20.00) = 5.48\times10^{-3}$ mol **(1 mark)**
$m(NaOH) = n\times M = 5.48\times10^{-4} \times 40.0 =$ **0.219 g (1 mark)**

iv. The above amount of sodium hydroxide was present in 4.156 g of the product, therefore in 1.00 kg = 1000.0 g
$m(NaOH) = 0.219 \times (1000/4.156) =$ **52.7 g kg^{-1} (1 mark)**

Question 3 (7 marks, 9 minutes)

a. Plants carrying out photosynthesis **(1 mark)**.
Carbon dioxide dissolving in the oceans or other water based features **(1 mark)**.

b. Solution A: **Hydrogen peroxide**, H_2O_2 **(1 mark)**.
Solid B: Catalyst such as **manganese(IV) oxide**, MnO_2 **(1 mark)**.

c. Most industrial oxygen is prepared by the fractional **distillation of liquid air (1 mark)**.

d. **[Mark allocation: All four correct = 2 marks, two or three correct = 1 mark]**

Property			
Odour		Odourless	
Solubility in water at 25 °C			Slightly soluble
pH of an aqueous solution	Neutral		
Flammability			Supports combustion

Note: Oxygen itself does not burn, other materials burn in oxygen.

Question 4 (7 marks, 9 minutes)

a. Oxygen is given the formal oxidation number of -2.
The formula for the species is: Cr_2O_3
Since the overall charge on the compound is zero, then let the oxidation number for the chromium be equal to x. Therefore:
$2x + 3\times(-2) = 0 \Rightarrow 2x = 6 \Rightarrow x = 3$ (III)
The **formal oxidation number of the chromium is three**, this being the chemical formula for chromium(III) oxide **(1 mark)**.

b. **i.** Referring to the Electrochemical Series (Table 2: VCE Chemistry Data Book), or an activity series, it can be seen that **zinc metal is a stronger reductant than iron, more reactive**, therefore it will **undergo corrosion reactions in preference to the iron (1 mark)**.

ii. Since the zinc is still electrically connected at some part of the steel sheet, then it will still offer protection to the iron as it will be oxidised in preference **(1 mark)**. *Note: Unlike tin plating of steel cans, which will corrode when the tin layer is broken, galvanising does not result in corrosion of the steel when the zinc layer is broken.*

c. **i.** Referring to the Electrochemical Series (Table 2: VCE Chemistry Data Book), or an activity series, silver ions are the stronger oxidant, therefore these will undergo **reduction** in half-cell A **(1 mark)**.

ii. In half-cell B the nickel metal will be oxidised.
$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$ **(1 mark)**

iii. The two half-equations are:

Reduction: $Ag^+(aq) + e^- \rightarrow Ag(s)$

Oxidation: $Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$

The overall equation can be obtained by multiplying the reduction half-equation by two and adding so that electrons are eliminated in the overall equation.

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

iv. Since electrons are released in the oxidation half-reaction and consumed in the reduction half-reaction, **the electrons will flow from the nickel electrode through the external circuit (meter) to the silver electrode**. **(1 mark)**

Question 5 (6 marks, 7 minutes)

a. The conditions are not at STP or SLC, therefore the General Gas Equation is required.

$PV = nRT$

$V = 1.50$ L $T = -15$ °C $= -15 + 273 = 258$ K

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

$n(NH_3) = m/M = 4.28 / 17.0 = 2.52\times10^{-1}$ mol **(1 mark)**

$P = \dfrac{nRT}{V}$ = **360 kPa (1 mark)**

b. $V_m(SLC) = 25.4$ L mol^{-1} (Table 3: VCE Chemistry Data Book)

The reaction requires five mole of oxygen for each mole of phosphorous.

$n(O_2) = 5 \times 0.0050 = 0.025$ mol

At SLC: $V(O_2, \text{required}) = n\times V_m = 0.025 \times 24.5 = 0.61$ L **(1 mark)**

$V(O_2 \text{ remaining}) = 2.0 - 0.61 =$ **1.4 L (1 mark)**

c. $P_1 = 103$ kPa $V_1 = 0.58$ L $T_1 = 18 + 273 = 291$ K

$P_2 = 48$ kPa $V_2 = ?$ $T_2 = 410$ K **(1 mark)**

Using the combined gas equation: $\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$

$V_2 = \dfrac{P_1V_1T_2}{T_1P_2} = \dfrac{103\times0.58\times410}{291\times48}$ = **1.8 L (1 mark)**

Question 6 (4 marks, 5 minutes)

a. As the new material is obtained from readily available plant matter, this would be the use of a renewable raw material **(1 mark)**.

Since the new herbicide is extracted from plant material it would most likely be less toxic or readily broken down in the environment **(1 mark)**.

b. The use of catalysts generally lowers the energy requirements for the chemical process thereby making it more energy efficient **(1 mark)**.

Since the use of catalysts usually reduces the temperature and pressure that processes are carried out at, it will reduce the hazards involved in the process **(1 mark)**.

Question 7 (5 marks, 6 minutes)

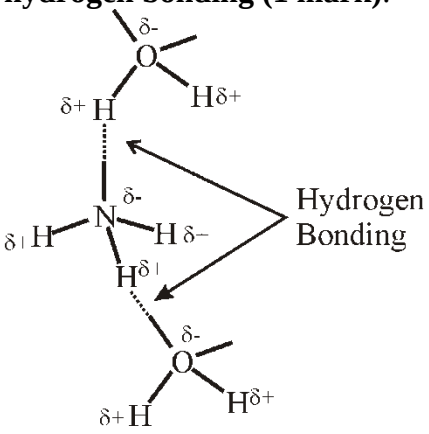
a. The ions present in the mixture are sodium, Na^+, zinc(II), Zn^{2+}, hydroxide, OH^-, and sulfate, SO_4^{2-}. Since all common sodium compounds are soluble in water, the precipitate must be zinc(II) hydroxide, $Zn(OH)_2$.
Either a full or ionic equation would be appropriate. (States **must** be shown) **(1 mark)**

Ionic: $Zn^{2+}(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s)$

Full: $ZnSO_4(aq) + 2NaOH(aq) \rightarrow Zn(OH)_2(s) + Na_2SO_4(aq)$

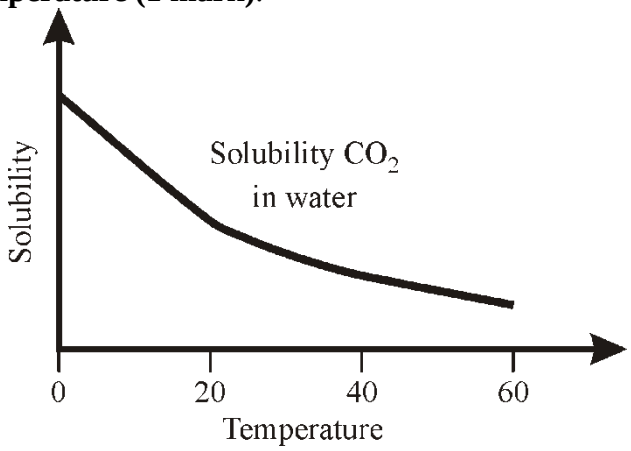
b. The steam from the boilers in the power station is being cooled in the cooling towers, therefore the water is absorbing energy from the steam. The property of water that this relies on is the **heat capacity**, which is high for water. **(1 mark)**

c. Both **water and ammonia are polar molecules**. Since the interactions involve hydrogen with nitrogen and oxygen then the **strongest interactions will involve hydrogen bonding (1 mark)**.



(1 mark)

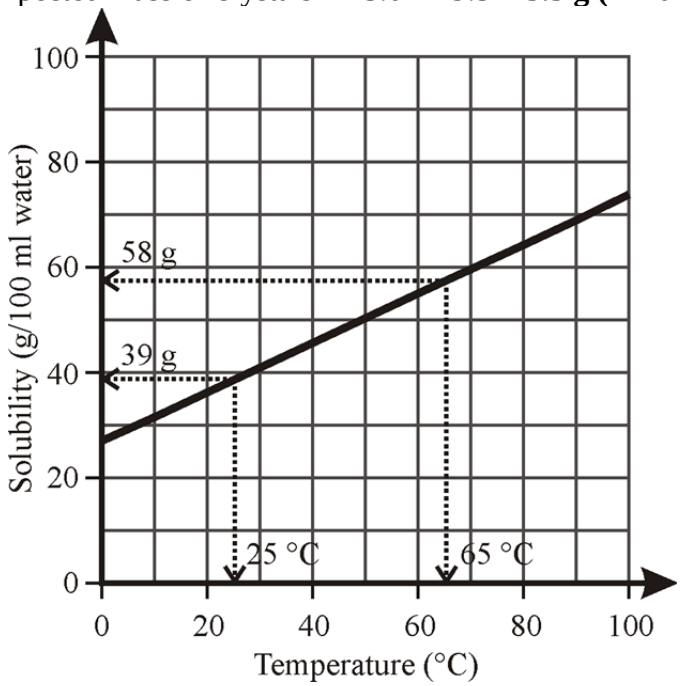
d. For aqueous solutions of gases the **solubility of the gas in the water decreases with increasing temperature (1 mark)**.



Question 8 (7 marks, 9 minutes)

a. **i.** From the solubility curve, the solubility of the compound at 65 °C is 58 g/100 mL. Therefore for 50 mL of solvent a mass of solute required to prepare a saturated solution would be 29 g. Since only 25 g of solute had been added this solution would be **unsaturated** at 65 °C **(1 mark)**.

ii. The solubility at 25 °C is 39 g/100 mL. Therefore for 50 mL solvent the mass of solute required to form at saturated solution would be 19.5 g.
The expected mass of crystals = 25.0 – 19.5 = **5.5 g (1 mark)**.



b. **i.** 1.00 kg = 1000 g
$n(CH_4) = 1000/16 = 62.5$ mol
$n(O_2) = 2 \times n(CH_4) = 2 \times 62.5 = 125$ mol
$V(O_2) = n \times V_m = 125 \times 24.5 =$ **3060 L (1 mark)**

ii. $V(CO_2) = ½V(O_2) = ½ \times 3060 =$ **1530 L (1 mark)**

iii. $n(H_2O) = 2n(CH_4) = 125$ mol
$m(H_2O) = n \times M = 125 \times (2 \times 1.0 + 16.0) = 2250$ g
$V(H_2O) =$ m/density = **2250 mL (1 mark)**

c. **i.** The pressure of a gas is a measure of the frequency of collisions that the gas particles make with the walls of the container. Increasing the temperature results in the average kinetic energy of the gas particles increasing, which in turn results in the gas particles travelling at a higher average speed. Because the particles are travelling faster then there will be a larger number of collisions with the container walls and this will result in a higher pressure **(1 mark)**.

ii. In a high pressure system there are more air particles in a given volume compared to those in a low pressure system. Therefore the gas particles will move from the high pressure area to the low pressure area to even out the distribution of particles. Winds are the movement of the air particles **(1 mark)**.

End of Suggested Answers