VCE CHEMISTRY 2014

YEAR 11 TRIAL EXAM

Unit 1 & Unit 2
Reading time: 15 minutes
Writing time: 2 hours 30 minutes

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	30	30	30
B	14	14	90
			Total 120

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STUDENT NUMBER

									Letter
Figures									
Words									

Student Name....……..... .....

VCE Chemistry 2014 Year 11 Trial Exam Unit 1/2

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 **30 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
Question 25	A	B	C	D	*Question 26*	A	B	C	D
Question 27	A	B	C	D	*Question 28*	A	B	C	D
Question 29	A	B	C	D	*Question 30*	A	B	C	D

VCE Chemistry 2014 Year 11 Trial Exam Unit 1/2

SECTION A – Multiple Choice Questions

(30 marks, 38 minutes)

This section contains 30 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.)

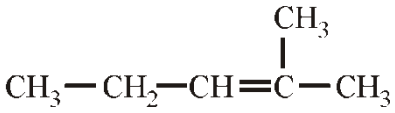
Question 1
Luminol, one of the key agents in producing chemiluminescence in light sticks, was analysed. The percentage by mass of carbon, hydrogen, nitrogen and oxygen were found to be 54.2 %, 3.95 %, 23.7 % and 18.1 % respectively. The empirical formula for luminol is
A. C_4H_3NO.
B. $C_5H_4N_2O$.
C. $C_9H_8N_3O_2$.
D. $C_8H_7N_3O_2$.

Question 2
In the fourth period of the Periodic Table, compared to gallium, selenium would display
A. more metallic characteristics and have a lower electronegativity.
B. more non-metallic characteristics and have a lower electronegativity.
C. more non-metallic characteristics and have a higher electronegativity.
D. more metallic characteristics and have a higher electronegativity.

Question 3
The structure of calcium oxide would involve
A. calcium and oxide ions arranged in a two dimensional lattice and held together by strong electrostatic forces within the lattice.
B. calcium oxide molecules with dipolar forces between the molecules.
C. calcium oxide molecules with weak dispersion forces between the molecules.
D. calcium and oxide ions arranged in a three dimensional lattice and held together by strong electrostatic forces.

Question 4
A sample of methane, CH_4, contains 4.82×10^{24} hydrogen atoms. The mass of the sample would be closest to
A. 26 g.
B. 32 g.
C. 128 g
D. 8 g.

Question 5
The systematic name for the hydrocarbon with the structure



is
A. 2-methylpent-2-ene.
B. 1,1-dimethylbut-1-ene.
C. 2-methylpent-3-ene.
D. 2-methylpentane.

Question 6
A neutral atom contains 60 electrons and 86 neutrons. The symbol for this isotope would be
A. $^{146}_{86}Rn$
B. $^{146}_{60}Nd$
C. $^{86}_{60}Nd$
D. $^{60}_{86}Rn$

Question 7
A molecule on the surface of a water drop will experience
A. an overall force of attraction towards the molecules beside it on the surface of the drop.
B. completely balanced forces of attraction.
C. an overall force of attraction towards the molecules inside the drop.
D. an overall force of attraction towards the gases that surround the drop.

Question 8
The electrical conductivity of metals is explained in the metallic bonding model by the free movement of
A. all of the electrons associated with the atoms in the lattice.
B. the ions in the metallic lattice.
C. electrons associated with defects in the positive ion lattice.
D. the delocalised electrons in the positive ions lattice.

Question 9
The physical properties of silicon carbide, SiC, are shown below.

Melting temperature	decomposes 2986 °C
Hardness (Moh's scale)	9.5
Density	3.23 g cm^{-3}
Electrical conductivity	insulator

The structure of silicon carbide would involve
A. a three dimensional network lattice with each silicon covalently bonded to four carbons and each carbon covalently bonded to four silicons.
B. covalently bonded silicon carbide molecules, with the molecules held together by dipolar forces.
C. a lattice of silicon and carbide ions.
D. a two dimensional network lattice with each silicon covalently bonded to three carbons and each carbon covalently bonded to three silicons.

Question 10
An element has two naturally occurring isotopes with mass numbers of 85 and 87. The abundance of the heavier isotope is about 30 %. The relative atomic mass for this element would be closest to
A. 86.0
B. 86.4
C. 85.3
D. 85.6

Question 11
The semistructural formulae for two compounds are

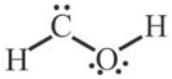
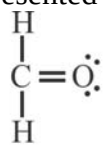
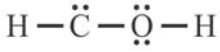
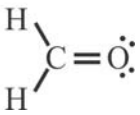
$$CH_3CH_2CHClCH{=}CHCH_2Cl \quad \text{and} \quad (CH_3)_2CHCH{=}CHCHCl_2$$

These two compounds are
A. sequential members in a homologous series of alkenes.
B. isomers because they have the same molecular formulae.
C. products of a reaction between chlorine and hexene.
D. isomers because they have the same empirical formulae.

Question 12
Metals will react with chlorine to form metal chloride compounds. In an experiment, a 1.369 g sample of a metal completely reacted with chlorine to form 4.173 g of the metal chloride. The percentage by mass of chlorine in this compound would be
A. 67.2 %.
B. 48.8 %.
C. 32.8 %.
D. 75.3 %.

Question 13
The monomers used to produce an addition polymer must
A. have functional groups at each end that will react and produce a small molecule.
B. have a carbon-oxygen double bond.
C. be alkanes.
D. have an unsaturated carbon-carbon bond.

Question 14
The forces present between the molecules in a sample of phosphine, PH_3, will be in order of decreasing strength
A. dipole-dipole interactions, hydrogen bonding and dispersion forces.
B. dipole-dipole interactions and dispersion forces.
C. dispersion forces, hydrogen bonding and dipole-dipole interactions
D. dispersion forces and dipole-dipole interactions.

Question 15
The structure for methanal, CH_2O, would be best represented by
A. 
B. 
C. 
D. 

Question 16
A technique that could be used to produce a sample of desalinated water is
A. evaporation.
B. boiling.
C. distillation.
D. precipitation.

Question 17
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 18
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 19
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 20
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 21
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 22
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 23
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 24
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 25
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 26
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 27
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 28

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 29

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 30

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.

End of Section A

VCE Chemistry 2014 Year 11 Trial Exam Unit 1/2

SECTION B – Short Answer Questions

(90 marks, 112 minutes)

This section contains fourteen questions, numbered 1 to 14.
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 (5 marks, 6 minutes)
Surface interactions play a significant role in many industrial and everyday processes.

a. Give an explanation why chemists have found that catalysts consisting of nanoparticles are more active than when a bulk sample of the same material is used. **1 mark**

b. Explain why the electrical conductivity of metal nanoparticles is less than that for a bulk sample of the same metal. **1 mark**

c. The leaves of some plants have a waxy coating. A plant scientist wished to use a water soluble leaf treatment for the plants, and dissolved the substance in water.

i. Why would this aqueous solution not be as effective as expected? **1 mark**

ii. What could the plant scientist do to achieve a better level of effectiveness with this water soluble treatment? **1 mark**

d. Explain why the surface energies for metals are considerably higher than those for polymeric materials such as polyethene. **1 mark**

Question 2 (7 marks, 9 minutes)

a. For the following molecules, draw diagrams to describe their geometries that show all bonding and non-bonding electrons, and state if the molecules will have permanent dipoles.

i. Hydrogen cyanide, HCN. **1 mark**

ii. Hydrogen sulfide, H_2S. **1 mark**

b. Alloying is a method used to alter the properties of metals. Explain the difference between the structures of interstitial and substitutional alloys. **2 marks**

c. Explain why solid sodium chloride does not conduct an electric current whereas it does conduct an electric current when molten. **2 marks**

d. Methane, CH_4, and ammonia, NH_3, are molecules with comparable molecular masses. However the boiling temperature for methane (-182.5 °C) is significantly lower than that for ammonia (-78 °). Give an explanation why this difference between the boiling temperatures of these two compounds occurs. **1 mark**

Question 3 (7 marks, 9 minutes)

a. John Dalton proposed an atomic theory in 1805. For each of the proposals of this theory listed below, state how the proposal compares with the current atomic theory.

i. All matter consists of indivisible atoms. **1 mark**

ii. Atoms of a particular element are identical in weight and have identical properties. **1 mark**

iii. The most stable compounds of two elements contain atoms in a one to one ratio. **1 mark**

b. Write the ground state electronic configurations for the following atoms or ions in terms of sub-shells.

i. A fluoride ion. **1 mark**

ii. A cobalt atom. **1 mark**

c. When the nucleus of an uranium-235 atom undergoes radioactive decay, it releases a helium-4 nucleus. Write the symbol for the other atomic particle that would be produced as a result of this decay. **1 mark**

d. What experimental evidence led Niels Bohr to first propose the electron shell model for atoms? **1 mark**

Question 4 (7 marks, 9 minutes)

a. Chlorine and sodium are two elements in the third period of the Periodic Table.

i. Explain, stating the reason, how the atomic radius of a chlorine atom compares with that of a sodium atom. **2 marks**

ii. Both of these elements will react with oxygen to form compounds with the chemical formulae of Cl_2O and Na_2O. Explain the differences in the bonding that would characterise these two compounds. **2 marks**

b. Magnesium and strontium are both members of Group 2 in the Periodic Table. Explain how the chemical reactivity of strontium would compare with that of magnesium. **2 marks**

c. Explain why neon is unreactive even under extreme conditions. **1 mark**

Question 5 (6 marks, 7 minutes)

a. **i.** Draw the structure for 2,2-dimethylbutane. **1 mark**

ii. Give the systematic name for another structural isomer of this hydrocarbon. **1 mark**

b. Write appropriate chemical equations for the following reactions of hydrocarbon compounds.

i. The complete combustion of butane, that is a component of LPG. **1 mark**

ii. The reaction between bromine and propene. **1 mark**

iii. The reaction of steam with ethene catalysed by the presence of phosphoric acid, H_3PO_4. **1 mark**

c. Write the molecular formulae for the next two hydrocarbon compounds following hexane in the alkane homologous series. **1 mark**

Question 6 (7 marks, 9 minutes)

a. What instrument is used to determine the isotopic composition of an element? **1 mark**

b. Determine the molar mass for propanoic acid, CH_3CH_2COOH. **1 mark**

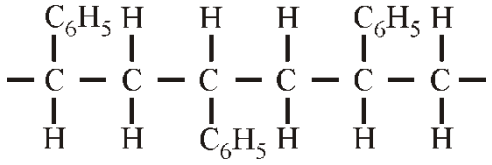
c. When hydrogen gas is passed over a heated sample of vanadium oxide, a chemical reaction occurs and vanadium and water vapour are produced.
When this reaction was carried out using a 2.370 g sample of vanadium oxide, 1.173 g of water was produced.

i. Determine the mass of oxygen present in this sample of vanadium oxide. **2 marks**

ii. Determine the empirical formula for this sample of vanadium oxide. **3 marks**

Question 7 (6 marks, 7 minutes)

a. Polystyrene is a widely used polymer and the diagram below shows the structure of a section of the polymer chain.



i. Draw the structure of the monomer used to produce polystyrene. **1 mark**

ii. Polystyrene foam is widely used as a packaging and insulation material. How would this material be produced from a bulk sample of polystyrene? **1 mark**

b. High-density polyethene, HDPE, and low-density polyethene, LDPE, are both produced from the same monomer, ethene.

i. What is the main difference in the structures of the polymer chains for these two materials? **1 mark**

ii. How does this difference in structure affect the physical properties of the polymers? **1 mark**

c. Polymer chemists often mention the term cross-linking.

i. Explain what this term refers to in polymer chemistry. **1 mark**

ii. What is the main effect that cross-linking has on the physical properties of a polymer? **1 mark**

Question 8 (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 9 (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**

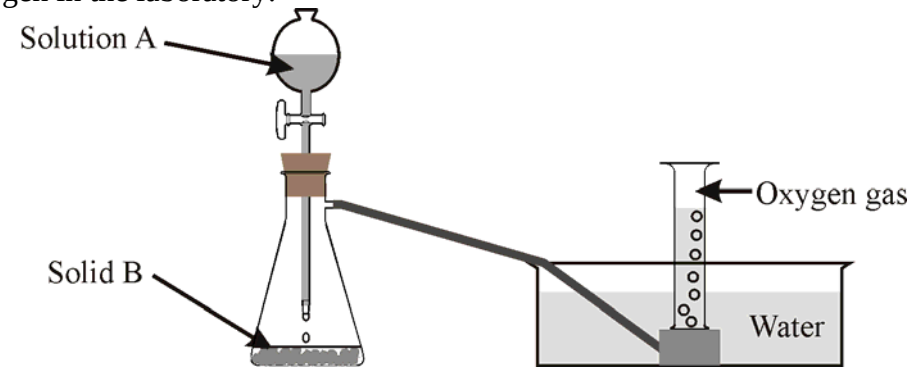
iii. Calculate the mass of sodium hydroxide in the sample. **2 marks**

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

Question 10 (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 11 (7 marks, 9 minutes)

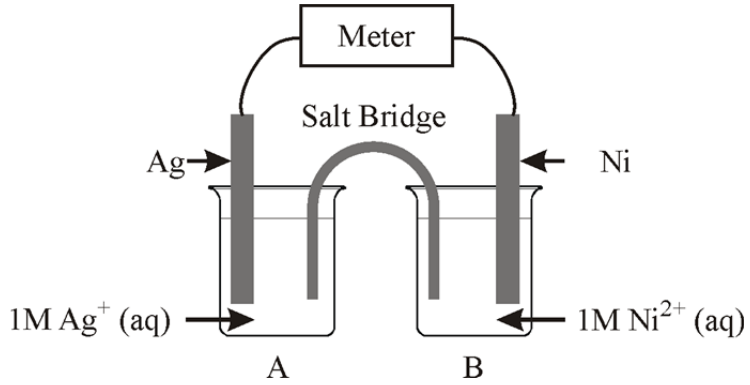
a. Determine the formal oxidation number for the chromium in the oxide with the chemical formula, Cr_2O_3. **1 mark**

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 12 (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 13 (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 14 (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**

End of Section B

End of Trial Exam

Suggested Answers

VCE Chemistry 2014 Year 11 Trial Exam Unit 1/2

SECTION A – Multiple Choice Answers

(1 mark per question)

Q1 **D** Determine the mole ratio by assuming 100 g of compound.

$$n(C) : n(H) : n(N) : n(O) = \frac{54.2}{12.0} : \frac{3.95}{1.0} : \frac{23.7}{14.0} : \frac{18.1}{16.0}$$

$$4.52 : 3.95 : 1.69 : 1.13$$

Divide all values by the smallest number, 1.13.

$$3.99 : 3.49 : 1.50 : 1$$

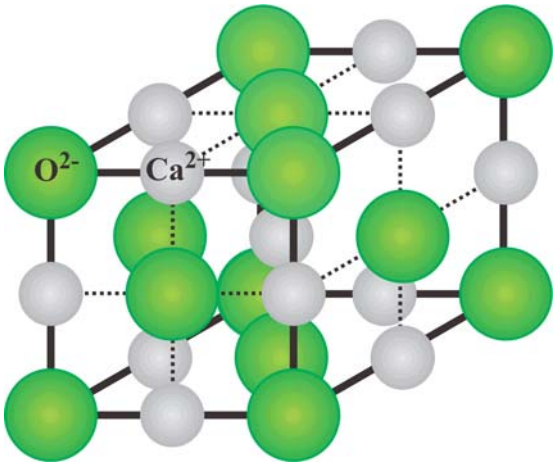
Since the ratio for H and N are close to half values then multiply all values by two.

$$8 : 7 : 3 : 2$$

$C_8H_7N_3O_2$.

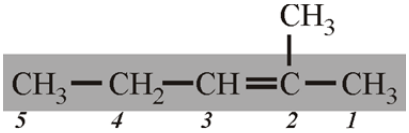
Q2 **C** Moving across a period in the periodic table, the non-metallic characteristics of the elements increase. Since selenium is in Group 16, compared to gallium in Group 13, selenium will exhibit more non-metallic characteristics.
The core and effective nuclear charge of the atoms increases moving across a period in the Periodic Table. Since the electronegativity is a measure of an atom's ability to attract an electron into its outer shell, then the electronegativity will increase moving across a period. (Electronegativities: Ga = 1.81, Se = 2.55)

Q3 **D** Calcium oxide, CaO, is an ionic compound because it involves metallic and non-metallic elements. Ionic compounds have the ions arranged alternating in a three dimensional lattice. There are strong electrostatic forces between the positive and negative ions throughout the lattice. This strong bonding between the ions results in ionic compounds having high melting temperatures and being hard brittle crystalline solids.



Q4 **B** The molar mass of methane would be:
$M(CH_4) = 12.0 + 4\times1.0 = 16.0$ g mol^{-1}
$N(H) = 4.82\times10^{24}$ atoms
$n(H) = N(H)/N_A = 4.82\times10^{24} / 6.02\times10^{23} = 8.0$ mol
$n(CH_4) = n(H)/4 = 8.0/4 = 2.0$ mol
$m(CH_4) = n\times M = 2.0 \times 16.0 =$ **32 g**

Q5 **A** The hydrocarbon contains a carbon-carbon double bond therefore is an alkene. Locate the longest carbon-carbon atom chain containing the carbon-carbon double bond and number the carbon atoms from the end that gives the first carbon atom in the double bond the smaller number.



There are five carbon atoms in the longest chain, with the carbon-carbon double bond between carbon atoms 2 and 3 ⇒ **pent-2-ene**
A methyl group is attached to carbon atom number 2 ⇒
2-methylpent-2-ene

Q6 **B** The neutral atom contains 60 electrons, therefore the nucleus will contain 60 protons. The atomic number will be 60. Referring to the Periodic Table (Table 1: VCE Chemistry Data Book) this element would be neodymium, Nd.
The mass number is the number of protons plus neutrons in the nucleus.
A = 60 + 86 = 146
$^{146}_{60}$Nd

Q7 **C** The molecules on the surface of the drop experience forces of attraction towards the molecules that surround them. Because there are no water molecules above the surface, this will result in an overall force of attraction towards the inside of the drop.

Q8 **D** The metallic bonding model considers metals as a three dimensional lattice of positive ions surrounded by delocalised electrons. The electrical conductivity of metals can be explained by the free movement of these delocalised electrons within the positive ions lattice.

Q9 **A** Silicon and carbon are both non-metals, therefore the bonding expected to be present in silicon carbide would be covalent. The physical properties of silicon carbide indicate that it is a three dimensional network lattice. Both carbon and silicon are in the same group in the Periodic Table and have four valence electrons, therefore would be expected to form four carbon-silicon covalent bonds. The structure of silicon carbide is similar to that for diamond, with alternating carbon and silicon atoms.

Q10 **D** The relative atomic mass is the weighted average of the isotopic masses.
The isotopic masses are close to the mass numbers for the element. Therefore the relative atomic mass for this element would be:
A_r = (85 × 70/100) + (87 × 30/100) = **85.6**

Q11 **B** Both compounds have the same molecular formula, $C_6H_{10}Cl_2$, but the atoms are arranged in a different manner therefore they are **isomers**.
Isomers are different structural arrangements of the atoms in compounds with the same **molecular formulae**.
While both compounds have the same empirical formula, the empirical formula is the lowest whole number ratio of the atoms present and not what atoms are actually present in the compound.

Q12 **A** m(compound) = 4.173 g
m(chlorine) = m(compound) – m(compound) = 4.173 – 1.369 = 2.804 g
%(chlorine) = m(chlorine)/m(compound) × 100/1
%(chlorine) = (2.804 / 4.173) × 100/1 = **67.2 %**

Q13 D The monomers used to produce addition polymers must be unsaturated molecules. In the reaction a pair of electrons from the carbon-carbon double bond are rearranged and new bonds are formed linking the monomer units. The monomer used to produce polyethene is ethene, $CH_2=CH_2$.

Q14 B The electronegativity of phosphorous is slightly greater than that of hydrogen, therefore each phosphorous-hydrogen bond will be polar. Since the molecule will be similar to that of ammonia, due to the lone pair of electrons on the phosphorous, then phosphine will be a dipolar molecule.
Dispersion forces, due to the instantaneous development of dipoles within particles, are present between all atoms and molecules.
Dipole-dipole interactions are stronger than dispersion forces.

Q15 D Carbon has four valence electrons therefore will form four covalent bonds. Oxygen has six valence electrons, therefore will form two covalent bonds and will have two lone pairs of electrons. Hydrogen forms a single covalent bond. The only possible arrangement to achieve the necessary bonding is to have the two hydrogens and the oxygen bonded to the carbon. The carbon-oxygen bond will be a double bond, thereby creating three regions of electron density around the central carbon. These will repel each other and the least energetic will be when the molecule is planar with a H-C-O angle of about 120 °. (*The experimentally measured H-C-O angle is 121 °)*

Q16 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.

Q17 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**.

Q18 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**

Q19 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**

Q20 **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.

Q21 **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**

Q22 **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.

Q23 **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: $2Ag^{+}(aq) + Cu(s) \rightarrow 2Ag(s) + Cu^{2+}(aq)$

Q24 **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 $^{7}/_{6}$**V**.

Q25 **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.

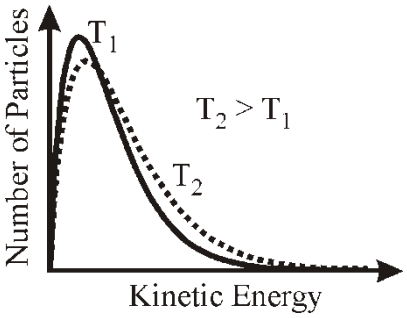
Q26 **D** Nitrogen in the soil is usually in the form of either the ammonium, NH_4^+, or nitrate, NO_3^-, ions. Ammonium and nitrate compounds are soluble in water, therefore heavy rains draining water into the groundwater will remove these ions from the upper layer of the soil.

Q27 **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**

Q28 **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.



Q29 **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.

Q30 **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:
$P_1V_1 = P_2V_2$

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

SECTION B – Short Answer (Answers)

Question 1 (5 marks, 6 minutes)

a. Nanoparticles have **large surface areas** thereby providing **more active sites** for catalysis to occur at **(1 mark)**.

b. Because nanoparticles are very small clusters of atoms, the numbers of delocalised electrons available within the particles is reduced, thereby lowering the number of mobile charge carriers available to carry the current **(1 mark)**.

c. **i.** The leaf surface will be hydrophobic and the aqueous solution will form droplets and run off the leaf, taking the treatment with it. The solution would not wet the surface. The water would form droplets because the force of attraction between water molecules is greater than that between the leaf and the water **(1 mark)**.

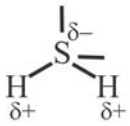
ii. Better wetting of the surface could be achieved by the adding of a surfactant or detergent to the solution **(1 mark)**.

d. The surface energy is a measure of the energy required to form a new surface. Metals have a lattice of positive ions surrounded by delocalised electrons, therefore there are strong electrostatic interactions bonding the metal together. In polymeric materials, the polymer chains are attracted to each other by weaker forces (such as dipole-dipole interactions or dispersion forces). Therefore the energy required to form a new metal surface would be larger because more energy would be needed to disrupt the forces between the particles **(1 mark)**.

Question 2 (7 marks, 9 minutes)

a. **i.** The number of valence electron on hydrogen, carbon and nitrogen are one, four and five respectively. Therefore hydrogen will form a single bond, carbon will form four and nitrogen three together with a pair of non-bonding electrons. There will be a **carbon-nitrogen triple bond** between the carbon and nitrogen. The molecule will have a **linear structure**. **Nitrogen is more electronegative** than either carbon or hydrogen, therefore the molecule will have a **permanent dipole (1 mark)**.

ii. Hydrogen and sulfur have one and six valence electrons respectively. Sulfur will form two bonds and have two pairs of non-bonding electrons, therefore there will be **four zones of electronic density around the sulfur**. This will result in a **bent structure** similar to that of water. Sulfur has a slightly higher electronegativity and because of the structure the molecule will have (like water) a **permanent dipole (1 mark)**.



b. In an **interstitial alloy** the atoms of the material added to the metal **occupy spaces between the atoms in the metal lattice (1 mark)**. These materials are generally smaller in size compared to the metal atoms.
The added material in **substitutional alloys replaces the metal atoms in the lattice (1 mark)**. The materials used in these alloys generally have sizes comparable with those of the metal atoms.

c. In **solid** sodium chloride the **ions are fixed within the lattice** and **cannot freely move**. This results in the solid not being a conductor of an electric current **(1 mark)**. When **molten the ions are free to move** around in the liquid, therefore since they are charged they can conduct an electric current **(1 mark)**.

d. The **boiling temperature of a molecular substance reflects the extent of the intermolecular forces**. In methane this is less than ammonia as evidenced by the lower boiling temperature. The **forces between the methane molecules only involve weak dispersion forces**, whereas in **ammonia there are additional dipole-dipole and hydrogen bonding interactions (1 mark)**.

Question 3 (7 marks, 9 minutes)

a. **i.** The concept of the indivisible atom has been replaced in modern atomic theory to atoms being made up of sub-atomic particles; electrons, protons and neutrons **(1 mark)**.

ii. The discovery of isotopes has shown that not all atoms of a particular element have the same weight (mass). While many of the physical properties of different isotopes are similar, there are some notable differences in the properties resulting from the nuclear constitution (knowledge about which was not known during Dalton's era) **(1 mark)**.

iii. This is probably the main proposal from Dalton's theory that attracts discussion, as water is clearly the most stable compound formed between hydrogen and oxygen and it has the formula of H_2O **(1 mark)**.

b. The order of sub-shell filling for ground state electronic configurations is $1s > 2s > 2p > 3s > 3p > 4s^{*} > 3d > 4s$ ……..
The maximum number of electrons in s, p and d sub-shells are 2, 6 and 10 respectively.
* A half or full 3d sub-shell will occur before a 4s sub-shell is filled due to lower electronic energies for these configurations, therefore for Cr …$3d^5 4s^1$ and Cu ….$3d^{10} 4s^1$

i. Fluorine (Z = 9)
The fluoride ion is F^-, therefore: **$1s^2 2s^2 2p^6$ (1 mark)**.

ii. Cobalt (Z = 27)
The 4s sub-shell fills before the 3d sub-shell
$1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$ (1 mark).
Note: The two electrons in the 4s sub-shell constitute the outer shell and it is these that are lost when cobalt forms the cobalt(II) ion.

c. Uranium-235 and helium-4 are represented by $^{235}_{92}U$ and $^{4}_{2}He$
When the decay occurs, the atomic number will decrease by 2 to 90, therefore the element will be thorium, Th.
The mass number will decrease by four to 231.
The symbol will therefore be: $^{231}_{90}Th$ **(1 mark).**

d. The experimental evidence that led Bohr to propose the electronic shell model was the emission spectra of the elements, particularly hydrogen **(1 mark)**.

Question 4 (7 marks, 9 minutes)

a. **i.** The atomic radius for a chlorine atom is **less** than that for a sodium atom because atomic radii decrease moving across a period in the Periodic Table **(1 mark)**. (Na 186 pm compared to Cl 99 pm.) Even though there are additional electrons in the outer shell of a chlorine atom, the atomic radius is smaller because of the **higher effective nuclear charge**, which attracts the electrons closer to the nucleus **(1 mark)**. The effective nuclear charge for a sodium atom is +1 compared to the +7 charge for the chlorine atom.

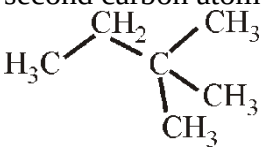
ii. **Cl_2O will be a covalent molecular compound** because it has been formed from two non-metal elements **(1 mark)**. In this molecule the chlorine will be joined to the oxygen by a single chlorine-oxygen covalent bond. Overall the molecule will have a bent shape, similar to that of water, with a Cl-O-Cl bond angle of about 111 °.
Na_2O will be an ionic compound because it is formed from metal and non-metal elements, therefore the structure will contain a lattice of sodium, Na^+, and oxide, O^{2-}, ions **(1 mark)**.

b. Strontium will be more reactive than magnesium because the reactivity of the metallic elements increases moving down a group in the Periodic Table **(1 mark)**. The reason for this difference in reactivity is because when metallic elements react, they act as reductants transferring electrons to the substance they are reacting with. Moving down the group these electrons are coming from a valence shell further from the nucleus, therefore these electrons are more easily transferred as the force attracting them to the nucleus decreases **(1 mark)**.

c. Neon is a Group 18 element in the Periodic Table and has the ground state electronic configuration of $1s^2 2s^2 2p^6$. Therefore the number of electrons in the outer shell is at its maximum, making it a very stable electronic configuration **(1 mark)**.
Note: Krypton, another Group 18 element, will react under extreme conditions with fluorine, however the compound formed is unstable.

Question 5 (6 marks, 7 minutes)

a. **i.** 2,2-dimethyl**butane** – The longest carbon atom chain in the compound contains four carbon atoms, joined by single carbon-carbon bonds.
2,2-dimethylbutane – There are two methyl groups, CH_3, attached to the second carbon atom from one end of the carbon atom chain.



(1 mark)

ii. Since this hydrocarbon is an alkane and contains six carbon atoms, all possible isomers will have the molecular formula C_6H_{14}. Possible isomers are listed below. **[1 mark if any one of these is selected]**

hexane	$CH_3CH_2CH_2CH_2CH_2CH_3$
2-methylpentane	$CH_3CH(CH_3)CH_2CH_2CH_3$
3-methylpentane	$CH_3CH_2CH(CH_3)CH_2CH_3$
2,3-dimethylbutane	$CH_3CH(CH_3)CH(CH_3)CH_3$

b. **i.** When a hydrocarbon is completely burnt it produces carbon dioxide and water.
Butane, C_4H_{10}.
Write down reactants and products.

$$C_4H_{10}(g) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$$

Balance number of carbon atoms.

$$C_4H_{10}(g) + O_2(g) \rightarrow 4CO_2(g) + H_2O(l)$$

Balance number of hydrogen atoms.

$$C_4H_{10}(g) + O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$$

Balance number of oxygen atoms

$$C_4H_{10}(g) + \tfrac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$$ **(1 mark)**

Combustion reaction chemical equations can be left at this stage or multiplied by two to remove fractional amounts of oxygen gas.

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$$

Ensure appropriate states are added.

ii. The reaction between bromine and an alkene results in the addition of bromine across the carbon-carbon double bond.

$$CH_3CH = CH_2(g) + Br_2(l) \rightarrow CH_3CHBrCH_2Br(l)$$ **(1 mark)**

States not critical in this reaction.

iii. The reaction of alkenes with steam results in the addition of H to one carbon atom and OH to the other carbon atom of the carbon-carbon double bond.

$$CH_2 = CH_2(g) + H_2O(g) \xrightarrow{H_3PO_4(l)} CH_3CH_2OH(g)$$ **(1 mark)**

c. The molecular formulae of successive members of a homologous series differ by CH_2. Therefore the since hexane has the molecular formula of C_6H_{14}, then heptane, **C_7H_{16}**, and octane, **C_8H_{18} (1 mark)**.

Question 6 (7 marks, 9 minutes)

a. A **mass spectrometer** is used to determine the isotopic composition of an element. **(1 mark)** The spectrometer is used to determine the relative isotopic masses of the isotopes and their abundances.

b. Propanoic acid, $CH_3CH_2COOH = C_3H_6O_2$

$M(C_3H_6O_2) = 3\times12.0 + 6\times1.0 + 2\times16.0 =$ **$74.0\ g\ mol^{-1}$ (1 mark)**

Units must be stated in order to receive the allocated mark.

c. **i.** $M(H_2O) = 2\times1.0 + 16.0 = 18.0\ g\ mol^{-1}$

$n(H_2O) = m/M = 1.173 / 18.0 = 6.517\times10^{-2}$ mol **(1 mark)**

$n(O) = n(H_2O) = 6.517\times10^{-2}$ mol

$m(O) = n\times M = 6.517\times10^{-2} \times 16.0 =$ **1.043 g (1 mark)**

Alternative calculations:

$m(O) = (M(O)/M(H_2O)) \times m(H_2O) = (16.0/18.0)\times 1.173 = 1.043$ g

ii. $m(V) = 2.370 - 1.043 = 1.327$ g **(1 mark)**

Determine molar ratio of the two elements

$$n(V) : n(O) = \frac{1.327}{50.9} : \frac{1.043}{16}$$

$= 2.608\times10^{-2} : 6.52\times10^{-2}$ **(1 mark)**

Divide both by the smaller value

$= 1 : 2.5$

Multiply both by 2

$= 2 : 5$

V_2O_5 (1 mark)

Alternative calculations:

%O = (1.043/2.370) × (100/1) = 44.0 %

%V = 100 – 44.0 = 56.0 %

Determine molar ratio of the two elements, assuming 100 g

$$n(V) : n(O) = \frac{56.0}{50.9} : \frac{44.0}{16}$$

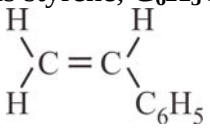
$= 1.10 : 2.75$

$= 1: 2.5$

$= 2: 5$ ***V_2O_5***

Question 7 (6 marks, 7 minutes)

a. **i.** The monomer required is styrene, **$C_6H_5CH=CH_2$ (1 mark)**.



ii. Polystyrene foam is produced by blowing a gas, such as carbon dioxide through a molten sample of polystyrene **(1 mark)**. This causes the polymer mixture to expand in volume and makes a lightweight material. *Prior to their banning, CFC's were used as the gas to expand the polymer.*

b. **i.** The main difference in the structures of HDPE and LDPE is the **amount of branching on the polymer chains**. HDPE has less branching so more polymer chains can be packed in a volume, therefore it will have a higher density **(1 mark)**.

ii. The larger amount of branching on the LDPE polymer chains makes the material softer and more flexible compared to HDPE **(1 mark)**.

c. **i.** Cross-linking refers to the formation of covalent bonds between polymer chains **(1 mark)**.

ii. Because there are strong covalent bonds between the polymer chains in cross-linked polymers, they become more rigid materials **(1 mark)**.

Question 8 (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 9 (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 10 (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 11 (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 12 (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 13 (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 14 (5 marks, 6 minutes)

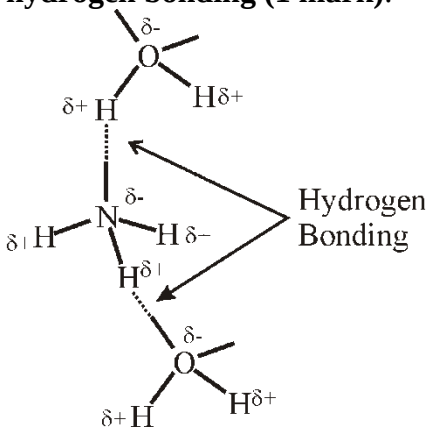
a. The ions present in the mixture are sodium, Na^+, zinc(II), Zn^{2+}, hydroxide, OH^-, and sulfate, SO_4^{2-}. Since all common sodium compounds are soluble in water, the precipitate must be zinc(II) hydroxide, $Zn(OH)_2$.
Either a full or ionic equation would be appropriate. (States **must** be shown)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

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

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

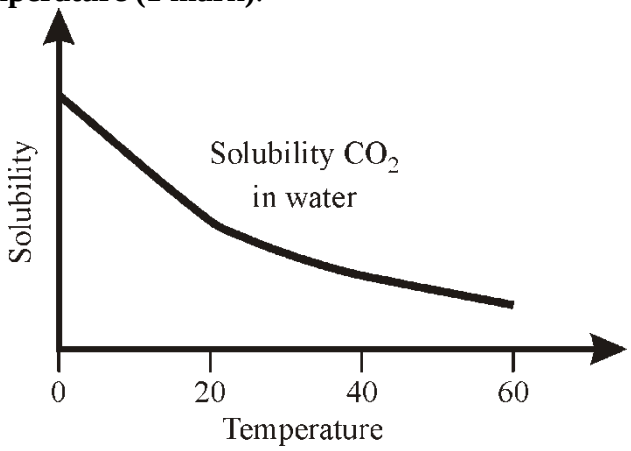
b. The steam from the boilers in the power station is being cooled in the cooling towers, therefore the water is absorbing energy from the steam. The property of water that this relies on is the **heat capacity**, which is high for water. **(1 mark)**

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)**.



End of Suggested Answers