Write your **student number** in the boxes above. **Letter**

Chemistry ½

Question and Answer Book

VCE Examination (Term 1 Mock) - April 2025

- Reading time is **15 minutes**
- Writing time is **2 hours**

Materials Supplied

- Question and Answer Book of 27 pages.
- Multiple-Choice Answer Sheet.

Instructions

- Follow the instructions on your Multiple-Choice Answer Sheet.
- At the end of the examination, place your Multiple-Choice Answer Sheet inside the front cover of this book.

Students are **not** permitted to bring mobile phones and/or any unauthorised electronic devices into the examination room.

Contents

Student's Full Name: _____

Student's Email: _____

Tutor's Name: _____

Marks (Tutor Only): _____

Section A

Instructions

- Answer **all** questions in pencil on the Multiple-Choice Answer Sheet.
- Choose the response that is **correct** or that **best answers** the question.
- A correct answer scores 1; an incorrect answer scores 0.
- Marks will **not** be deducted for incorrect answers.
- No marks will be given if more than one answer is completed for any question.
- Unless otherwise indicated, the diagrams in this book are not drawn to scale.

Question 1

Which of the following values has exactly 4 significant figures?

A. $43{,}553$

B. 0.2390

C. 4.32×10^4

D. 0.0004

Question 2

For the atom of ^{12}C, which of the following statements is false?

A. There are a total of 12 protons and neutrons in this atom.

B. The number of electrons would be less than the number of protons as the atom is charged.

C. The concept of moles is based on this atom.

D. The number of electrons in this atom is equal to the atomic number.

Question 3

Which of the following does the Schrödinger model most accurately present?

A. Electrons are found in fixed positions within shells.

B. Atoms are mostly made up of empty space.

C. Electron position is not fixed but found in regions called orbitals.

D. Atoms have a nucleus which consists of neutrons but no protons.

Question 4

Which of the following trends in the periodic table is true?

A. Moving across a period, electronegativity decreases.

B. Moving down a group, first ionisation energy increases.

C. Moving up a group, the metallic nature of an atom decreases.

D. The atomic radius of atoms decreases going from right to left across a period.

Question 5

What is the percentage composition of P in $\mathrm{H_3PO_4}$?

A. 65.31%

B. 3.06%

C. 31.63%

D. 33.54%

Question 6

Consider the reaction that creates ammonia gas.

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

Find the mass of ammonia that is formed from $3.42 \times 10^2\ g$ of hydrogen gas. Assume that nitrogen gas is in excess.

A. $1.938 \times 10^4\ g$

B. $1.938 \times 10^2\ g$

C. $1.938 \times 10^1\ g$

D. $1.938 \times 10^3\ g$

Question 7

Consider the reaction between aluminium chloride and lithium hydroxide.

$$\mathrm{AlCl_3 + 3LiOH \rightarrow Al(OH)_3 + 3LiCl}$$

If there is $2.45\ mol$ of $\mathrm{AlCl_3}$ and 4.50 moles of LiOH, what is the excess reagent and how much is it in excess by?

A. $\mathrm{AlCl_3}$ is in excess by $2.05\ mol$.

B. $\mathrm{AlCl_3}$ is in excess by $0.95\ mol$.

C. LiOH is in excess by $2.05\ mol$.

D. LiOH is in excess by $0.95\ mol$.

Question 8

What's the electron configuration for selenium written using Schrödinger's subshell notation?

A. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 4p^6\ 3d^8$

B. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 4p^6\ 3d^9$

C. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^8\ 4p^5$

D. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^4$

Question 9

Which of the following statements about ionic compounds is correct?

A. Ionic compounds are ductile.

B. Ionic solids are good electrical conductors in a solid state.

C. All salts are ionic compounds.

D. Ionic compounds have lower boiling points than covalent ones.

Question 10

$3.15\ g$ of zinc powder was reacted with $10.2\ g$ of O_2. How many g of O_2 remain unreacted?

A. 0.00

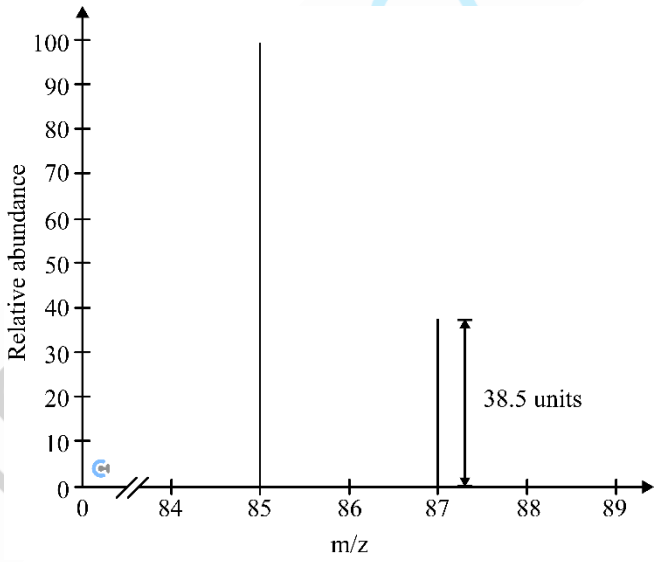
B. $8.66\ g$

C. $9.43\ g$

D. $9.80\ g$

Question 11

Given the following mass spectrum of rubidium nuclei, what's the % abundance of the radioisotope rubidium-87?



A. 27.8%

B. 38.5%

C. 40.0%

D. 61.5%

Question 12

How many niobium atoms are in $15\ g$ of Nb_2O_5?

A. 3.4×10^{22}

B. 6.8×10^{22}

C. 1.7×10^{23}

D. 9.03×10^{24}

Question 13

Which of the following statements is true about the allotropes of carbon?

A. Carbon forms 4 bonds with itself when forming graphite.

B. Diamonds are electrically conductive.

C. Graphite exists in layers held together by weak dispersion forces.

D. Diamond has a weak covalent network lattice.

Question 14

When a solution of barium chloride is mixed with a solution of sodium sulphate, what is the precipitate formed?

A. $NaBr$

B. $BaSO_4$

C. $NaCl$

D. Br_2SO_4

Question 15

Which of the following is the correct formula for ammonium carbonate?

A. NH_4CO_3

B. NH_3CO_3

C. $(NH_4)_2CO_3$

D. $NH_4(CO_3)_2$

Question 16

Which of the following molecules have a tetrahedral parent geometry?

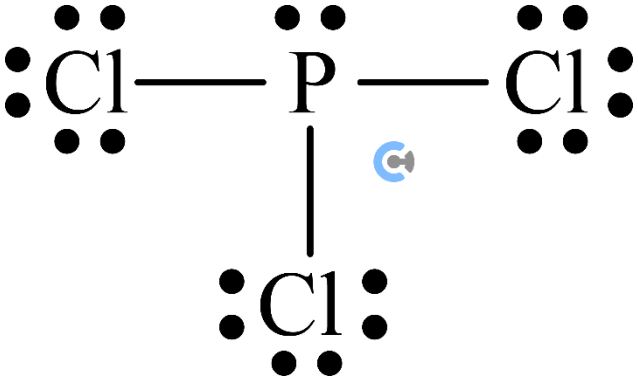
A. CCl_4

B. H_2O

C. NH_3

D. All of the above.

The following molecule relates to both Question 17 and Question 18



Question 17

Which of the following best describes the **bonds** within this molecule?

A. The bonds are ionic.

B. The bonds are polar covalent.

C. The bonds are non-polar covalent.

D. None of the above.

Question 18

Which of the following is **true** about the entire molecule?

A. It is non-polar as its geometry is tetrahedral.

B. There is no net dipole.

C. It can form dipole-dipole bonds.

D. It can form hydrogen bonds.

Question 19

Which of the following best describes why water is a liquid at room temperature?

A. It has strong electrostatic attraction between molecules.

B. It has strong dispersion forces.

C. It can exhibit hydrogen bonding.

D. It has strong covalent bonds.

Question 20

Which of the following compounds would best mix with water?

A. CCl_4

B. HCl

C. HF

D. C_6H_{14}

Question 21

Chlorine exists in 2 forms in nature: Cl-35 and Cl-37, with abundances of 25% and 75% respectively. Its relative atomic mass is:

A. 36.0

B. 36.5

C. 35.5

D. 50

Question 22

Which of the following is a correctly balanced equation?

A. $C_2H_5OH + O_2 \rightarrow CO_2 + H_2O$

B. $2C_2H_6O + 7O_2 \rightarrow 4CO_2 + 6H_2O$

C. $C_2H_5OH + 6O_2 \rightarrow 2CO_2 + 3H_2O$

D. $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

Question 23

What is/are the product(s) of a reaction between oxygen gas and magnesium metal?

A. MgO

B. Mg_2O

C. $Mg(OH)_2$

D. $Mg(OH)_2$ and H_2

Question 24

Which of the following best explains how NaCl dissolves in water?

A. It forms ionic bonds with water molecules.

B. It dissociates and the sodium ions form ion-dipole bonds with the hydrogen atoms in water molecules.

C. It ionises and the chloride ions form ion-dipole bonds with the oxygen atoms in water molecules.

D. The ionic bonds within the lattice are disrupted, and then ion-dipole bonds are formed between the ions and water molecules.

Question 25

Qualitative analysis in TLC is best described as:

A. Matching the R_f value of a substance with that of a known compound under identical conditions.

B. Matching the R_t of a substance with that of a known compound under identical conditions.

C. Determining concentrations of chemicals by constructing a calibration curve.

D. Identifying the most polar substance based on adsorption and desorption.

Question 26

Which of the following is **not** true regarding metal extraction and recycling?

A. Not all metals are recycled.

B. Metal recycling promotes a circular economy.

C. Most metals exist in their pure form in nature.

D. Metals are smelted to remove impurities.

Question 27

Which of the following is true regarding empirical and molecular formulae?

A. The empirical formula lists the actual number of atoms in a compound.

B. The molecular formula lists the ratio of atoms in a compound.

C. Two or more compounds can have the same empirical formula.

D. A substance's empirical formula cannot be the same as its molecular formula.

Question 28

The metallic bonding model is best described as:

A. Cations and anions held together by electrostatic attraction.

B. Cations and a sea of delocalised electrons, both of which are moving freely.

C. Cations arranged in a lattice, surrounded by a sea of delocalised electrons.

D. Metals bonding to one another via dispersion forces.

Question 29

Why is fluorine found in the p-block of the periodic table?

A. It has 6 valence electrons.

B. It has a partially filled P subshell as it's outmost shell.

C. Because it is in period 2.

D. Because it is in group 17.

Question 30

Copper is often used in electrical wiring. This can be best attributed to the fact that it is:

A. Ductile

B. Malleable

C. Brittle

D. A thermal conductor

Section B

Instructions

- Answer all questions in the spaces provided.
- Write your responses in English.
- Give simplified answers to all numerical questions, with an appropriate number of significant figures; unsimplified answers will not be given full marks.
- Show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working.
- Ensure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example, $\mathrm{H_2(g)}, \mathrm{NaCl(s)}$.
- Unless otherwise indicated, the diagrams in this book are not drawn to scale.

Question 1 (8 marks)

Betty is creating a model of the atom for her school project and wishes to produce a representation of Bohr's Model. To do this, she picks $^{14}\mathrm{N}$ as her reference atom.

a. Explain what the Bohr's Model is in reference to $^{14}\mathrm{N}$. Ensure to explain the electron distribution and key aspects of the model. 2 marks

_____

_____

_____

_____

b. Betty wonders how Bohr's model was discovered. Explain how the production of an emission spectrum from a flame test links to key aspects of the model. 2 marks

_____

_____

_____

_____

c. Betty's competitor, Linda, presents a model instead using the Schrödinger's Model.
Provide the subshell configuration for the following atoms:

i. Na 1 mark

_____

ii. Cl 1 mark

_____

iii. Cr 1 mark

_____

d. State the condensed Schrödinger notation of potassium. 1 mark

_____

Question 2 (5 marks)

Nash is investigating moles and masses of two different compounds.

a. He first investigated sulfuric acid (H_2SO_4).

i. Find the molar mass of sulphuric acid. 1 mark

_____

_____

ii. Find the mass of $6.16\ mol$ of sulphuric acid. 1 mark

_____

_____

b. He then investigates oxygen gas (O_2).

i. Find the amount, in mol, of oxygen atoms in $15.00\ g$ of oxygen gas. 2 marks

_____

_____

_____

ii. State the number of oxygen atoms in $15.00\ g$ of oxygen gas. 1 mark

_____

_____

Question 3 (8 marks)

The periodic table, aside from presenting all elements, is arranged to observe certain trends to predict the properties of elements.

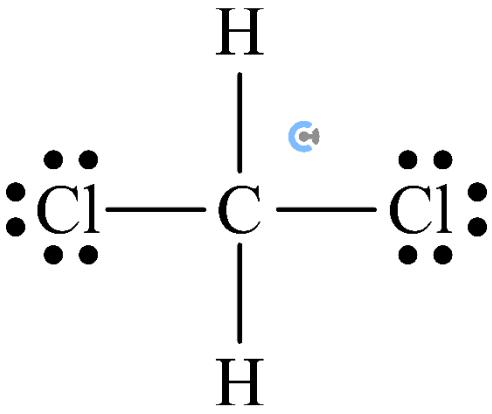
a. Between $\mathrm{Na}(s)$ and $\mathrm{Cs}(s)$, explain which of these metals is more likely to react. Make references to relevant trends in your answer. 3 marks

b. Identify and explain one key property of group 18 compounds. 2 marks

c. What occurs to the electronegativity of atoms moving from left to right across a period? Explain your answer with reference to at least two other trends. 3 marks

Question 4 (7 marks)

A molecule of CH_2Cl_2 is shown below:



a. Complete the table below regarding the molecule shown. 2 marks

Parent Geometry	Molecular Geometry

b. Explain whether the molecule above is polar or non-polar. Refer to its geometry and bonds. 3 marks

c. State the types of intermolecular bonds this molecule can undergo, and justify why. 2 marks

Question 5 (6 marks)

a. Draw the metallic lattice structure of calcium metal below, ensuring that the diagram has exactly 10 electrons. Ensure to draw and label any relevant forces of attraction. 3 marks

b. With reference to its structure, explain why metals such as calcium are malleable. 3 marks

Question 6 (8 marks)

Hydrofluoric acid, also known as HF, is an acidic substance. We usually dilute it in several ways to make it safer for human handling.

a. The structure of HF is to be investigated.

i. Draw the Lewis Structure of HF. 1 mark

ii. Draw the polarity arrow on HF above. 1 mark

b. Explain whether HF is polar or non-polar. 2 marks

c. State what sort of intermolecular bonds HF molecules can make. 1 mark

d. Would we expect HF to have a higher boiling point than HBr? Justify your answer. 3 marks

Question 7 (12 marks)

Salts refer to ionic compounds, which are made up of a metal cation and a non-metal anion. One classic example of salt is $NaCl$, which is widely used and known as table salt, used in cooking and preservation.

a. Explain the structure of a salt crystal, with reference to the ionic bonding model. Ensure to identify any relevant intramolecular forces. 2 marks

Note: You may refer to the specific bonding within $NaCl$ to aid your explanation.

_____

_____

_____

_____

b. Would solid $NaCl$ be electrically conductive? Why or why not? 2 marks

_____

_____

_____

c. Despite being hard, when salt crystals are subject to pressure, they crumble and break away, instead of bending and stretching. Identify this property, and explain why it is the case with reference to the ionic bonding model. 2 marks

_____

_____

_____

d. Another salt, magnesium nitrate is also commonly used in society.

i. Write the formula of magnesium nitrate. 1 mark

_____

ii. Provide the fully balanced dissociation reaction for this salt, when it is mixed with water. 1 mark

_____

e. An aqueous solution of this salt is then combined with $KOH\ (aq)$.

i. Write the balanced full equation taking place. 2 marks

_____

ii. State the identity of any spectator ions. 1 mark

_____

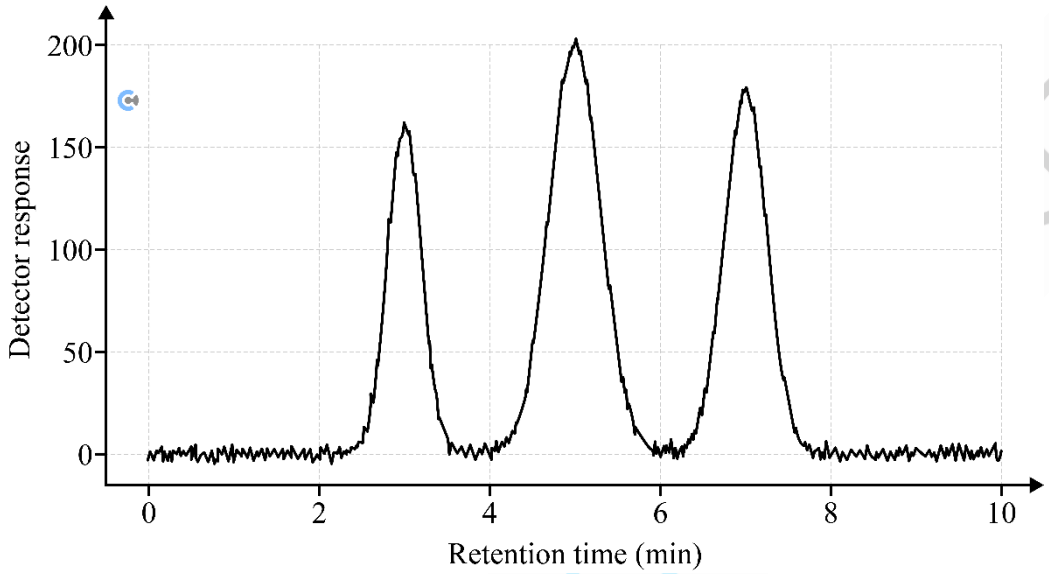
iii. Write the balanced net ionic equation. 1 mark

_____

Question 8 (5 marks)

Kevin was on his way to teach his Chemistry $1/2$ class and was pulled over for a random breath test. It is known that alcohol (ethanol) has a retention time of 6 minutes on a particular HPLC set-up.

Below is the chromatogram obtained from Kevin's blood sample when run under the same set-up under identical conditions:



a. State whether Kevin has ethanol in his bloodstream. Justify your answer. 1 mark

b. The large peak in the middle corresponds to glucose. If Kevin wanted to determine the concentration of glucose in his blood, explain the steps he would have to perform to undertake this analysis. 4 marks

Question 9 (4 marks)

An experiment was conducted to experimentally determine Avogadro's number using a sample of nitric acid, HNO_3.

a. Calculate the moles of nitric acid in a $7.31 \times 10^3\ mg$ sample. 2 marks

b. Hence, given that we determine that there are approximately 1.95×10^{23} atoms of oxygen in the sample, calculate the experimental value of Avogadro's Number. 2 marks

Question 10 (5 marks)

Arjun is experimenting with his new mass spectrometer in his garage, and adding different compounds into the machine to observe the spectra which are produced.

a. Explain what mass spectrometry is primarily used for. 1 mark

_____

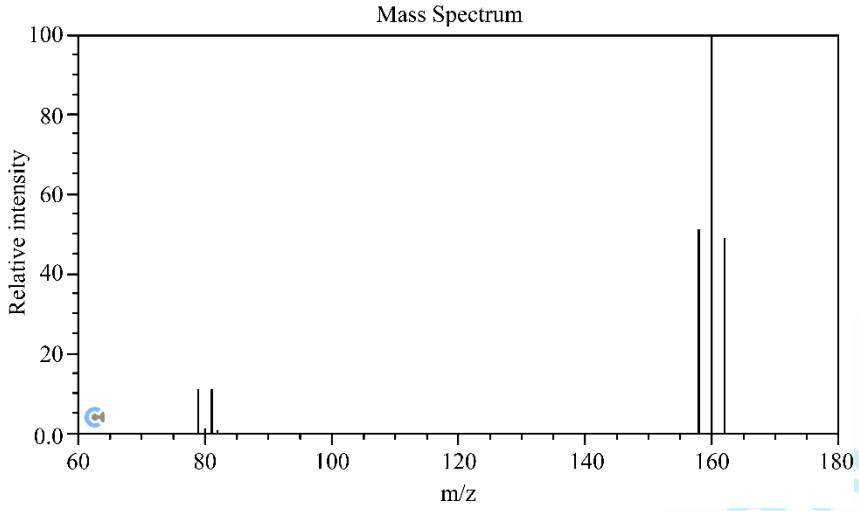
_____

b. State what is meant by the m/z ratio. State what it is used to reveal. 1 mark

_____

_____

c. Below is a graph of the spectra produced after placing an unknown **diatomic** molecule into the mass spectrometer.



i. What is the likely identity of the molecule? 1 mark

_____

_____

ii. Explain the presence of the two side peaks around the major peak at $160\ m/z$. Justify your answer. 2 marks

_____

_____

_____

Question 11 (8 marks)

Consider a compound that is comprised of 13.0% hydrogen, 52.2% carbon and the remainder being oxygen.

a. Determine the empirical formula of this substance. 3 marks

b. Given that the molar mass of the molecule is $46\ g\ mol^{-1}$, state the molecular formula. 1 mark

c. Given the equation below: 4 marks

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$

If $3.56\ g$ of the substance reacts in excess oxygen, calculate the total mass of products produced by the reaction.

Question 12 (7 marks)

Marble chips, typically comprised of $CaCO_3$, can react with hydrochloric acid to create calcium chloride.

a. What is the percentage composition of carbon in $CaCO_3$? 1 mark

_____

_____

_____

b. Consider a $5.33\ g$ sample of $CaCO_3$ and $1.53\ g$ of HCl reacting according to this reaction.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(s) + CO_2(g) + H_2O(l)$$

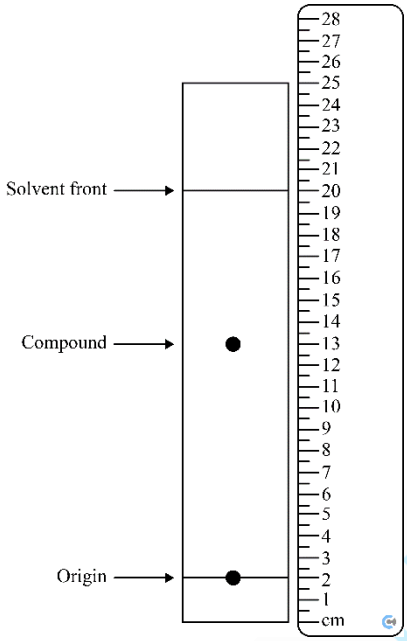
i. Determine the limiting and excess reagent of this reaction. 2 marks

ii. Hence, calculate the amount of $CaCl_2$ produced, in g. 2 marks

iii. State the amount, in grams, of excess reagent left over after the reaction. 2 marks

Question 13 (7 marks)

The following chromatogram was obtained for a certain compound.



a. Calculate the R_f value for the compound. 1 mark

b. If the solvent used in this setup was H_2O, then what can you conclude about the relative polarity of the compound? Justify your answer with reference to miscibility and intermolecular bonding. 3 marks

c. Consider that subsequent compounds were analysed under the same conditions.

Mark on the chromatogram above where these components should be located.

i. Compound A, which has an R_f value of 0.35. 1 mark

_____

_____

ii. Compound B has an R_f value of 0.89. 1 mark

_____

_____

d. State a major difference between TLC and paper chromatography. 1 mark

_____

_____