Neap:

Trial Examination 2007

VCE Chemistry Unit 1

Written Examination

Suggested Solutions

SECTION A: MULTIPLE-CHOICE QUESTIONS

1	A	**B**	C	D
2	A	**B**	C	D
3	A	B	**C**	D
4	A	B	**C**	D
5	A	**B**	C	D
6	A	B	**C**	D
7	A	B	C	**D**
8	**A**	B	C	D
9	A	B	C	**D**
10	A	B	C	**D**

11	**A**	B	C	D
12	**A**	B	C	D
13	A	B	**C**	D
14	**A**	B	C	D
15	A	B	**C**	D
16	A	**B**	C	D
17	**A**	B	C	D
18	A	**B**	C	D
19	A	B	C	**D**
20	A	B	C	**D**

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Question 1 B

The models shown are

- I Bohr's shell model (1913);
- II The modern 'probability' model (post-1920);
- III Thomson's plum pudding model (1800s); and
- IV Rutherford's planetary or nuclear model (1910).

Question 2 B

If carbon-12 has a mass of 12 units, oxygen-16 has a mass of 16 units.

$\therefore$ if carbon-12 has a mass of 40 units, oxygen-16 will have a mass of $\frac{40}{12} \times 16 = 53$ units.

Question 3 C

Boiling temperatures of molecular substances are determined by the strength of the intermolecular bonding. Thus hydrogen has a low boiling point due to the weak dispersion forces between the small, non-polar molecules. Hydrogen fluoride has a higher than expected boiling point due to the unusual strength of the hydrogen bonds between molecules. Ammonia has highly polar molecules that form hydrogen bonds with water molecules. Thus it is the intermolecular bond type that explains this property. Decomposition of methane requires the breaking of strong covalent intramolecular bonds, not intermolecular bonds.

Question 4 C

In the symbol ${}^{A}_{Z}X$, 'Z' represents the number of protons (39 in this case). 'A' represents the number of nucleons (protons + neutrons = 89 in this case). Hence the number of neutrons is 89 – 39 = 50. The 2+ charge indicates that two of the 39 electrons have been lost, hence 37 remain.

Question 5 B

The atom shown has 30 electrons and so has 30 protons (atomic number 30), so **A** is not the required response. X has two outer-shell electrons and so is likely to be metallic (so **D** is not the answer) and form a cation with a 2+ charge (so **C** is not the answer). X has electrons in the 3d subshell, and has two 4s electrons. This means that element X is in Period 4 (four occupied electron shells), and is a transition metal. **B** is therefore incorrect, and so is the required response.

Question 6 C

$$n(Al_2(SO_4)_3) = \frac{1}{2} \times n(Al) = \frac{1}{2} \times 0.50 = 0.25 \text{ mol}$$

$$n(O) = 12 \times n(Al_2(SO_4)_3) = 12 \times 0.25 = 3.0 \text{ mol}$$

$$m(O) = n \times M = 3.0 \times 16.0 = 48 \text{ g}$$

Question 7 D

Metals lose one, two or three electrons to form cations. These cations have approximately the same mass as the atoms, because electrons have very little mass. The electrons are lost from the outer shell, giving the ions a smaller radius than the atoms. Statements **A** and **C** are therefore correct. Non-metals gain one, two or three electrons to form anions. Statement **C** is therefore correct. These anions tend to be very stable, as they have an outer-shell octet of electrons. Therefore statement **D** is incorrect and so is the required response.

Question 8 **A**

Relevant calculations are shown below.

A $n(\text{N}) = n(\text{NaNO}_3) = 1.4 \text{ mol}$

B $n(\text{N}) = 2 \times n(\text{N}_2\text{O}) = 2 \times \dfrac{N}{N_\text{A}} = \dfrac{2 \times 5.0 \times 10^{23}}{6.0 \times 10^{23}} = 1.7 \text{ mol}$

C $n(\text{N}) = \dfrac{N}{N_\text{A}} = \dfrac{1.2 \times 10^{24}}{6.0 \times 10^{23}} = 2.0 \text{ mol}$

D $n(\text{N}) = 2 \times n(\text{N}_2) = 2 \times \dfrac{m}{M} = 2 \times \dfrac{22}{28} = 1.6 \text{ mol}$

Question 9 **D**

The correctly balanced equation is

$$2\text{NaOH(aq)} + \text{H}_2\text{(g)} + \text{Cl}_2\text{(g)} \rightarrow 2\text{NaCl(aq)} + 2\text{H}_2\text{O(l)}$$

Question 10 **D**

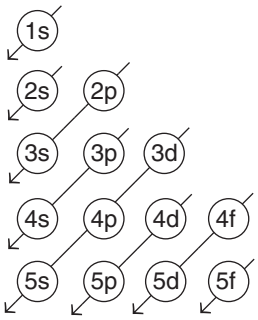
Alkanes have non-polar, saturated molecules which form dispersion forces between the molecules. Thus statements **A** and **B** are correct. Boiling points of alkanes increase with increasing size due to the increased strength of dispersion forces. Thus statement in **C** is correct. Being non-polar, alkanes do not dissolve in water, and do not ionise in water. Thus statement **D** is incorrect and so is the required response.

Question 11 **A**

Electronegativity and ionisation energy increase across a period due to the increasing core charge, and so the increasing attraction for outer-shell electrons (hence not **B** or **D**). This increasing attraction leads to a decrease in atomic radii (therefore answer **A**). Melting point tends to increase and then decrease across a period, but does not show an entirely regular pattern (therefore not **C**).

Question 12 **A**

The diagram below shows the order of filling.



Question 13 **C**

The number of protons and electrons in the neutral atom is equal. The numbers of protons and neutrons are usually close, but not necessarily equal (therefore not answer **A** or **B**). The total mass of the electrons is negligible compared to the total mass of the protons (therefore not answer **D**). Protons and neutrons have very similar masses.

Question 14 A

Five occupied electron shells means that the element is in Period 5 of the Periodic Table.
Hence Sr (element 38).

Question 15 C

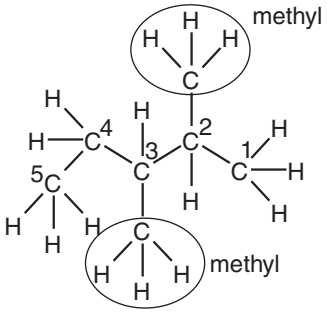
High melting point suggests strong bonding between particles. Strong bonding leads to hardness. Conductivity, malleability and chemical reactivity cannot be predicted from knowledge of bond strength alone.

Question 16 B

Discrete energy levels for electrons is a feature of Bohr's model of the atom. Bohr experimented with emission spectra. Scattering of α -particles led to Rutherford's planetary/nuclear model. Discharge tube experiments led to Thomson's plum pudding model. Deflection of ions in a magnetic field is the basis of operation of the mass spectrometer, used to determine relative isotopic masses.

Question 17 A

Number the carbon atoms as shown to give side groups the smallest possible numbers. Identify the side groups as shown. The molecule is an isomer of heptane (C_7H_{16}), but this is not its systematic name.

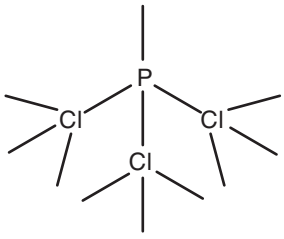


Question 18 B

CO_2 and HBr are linear, so bond angles are 120°. CH_4 is a pure tetrahedral structure. NF_3 is pyramidal. Repulsions by the lone pair lead to angles of less than that of a pure tetrahedron.

Question 19 D

From the diagram shown, there are ten non-bonding outer-shell pairs in total.



Question 20 D

N_2O_4 reduces to NO_2, thus it is not an empirical formula. The other formulas shown are all the simplest, whole number ratios of the atoms present, and so are all empirical formulas.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. $C : H : O = \frac{40.0}{12.0} : \frac{6.7}{1.0} : \frac{53.3}{16.0} = 3.33 : 6.7 : 3.33 = 1 : 2 : 1$

The empirical formula is CH_2O. 2 marks

b. $M(\text{compound}) = \frac{m}{n} = \frac{2.84}{0.047} = 60 \text{ g mol}^{-1}$ 1 mark

c. molecular formula = $(\text{empirical formula})_x$, where $x = \frac{\text{RMM}}{\text{EFM}} = \frac{60}{30} = 2$

The molecular formula is $(CH_2O) \times 2 = C_2H_4O_2$. 1 mark

Total 4 marks

Question 2

a. **i.** Z *(Ca loses two electrons to give the electronic configuration of Ar.)* 1 mark

ii. W *(Al forms a +3 ion.)* 1 mark

iii. U *(6×10^{23} atoms of the given mass will have a mass of 12 g, hence C.)* 1 mark

iv. V *(Electronegativity increases across periods and up groups.)* 1 mark

b. **i.** Sodium and chlorine both have three occupied electron shells. The core charge of chlorine (+7) is much greater than that of sodium (+1). 1 mark

The increased attraction for the outer-shell electrons by the greater core charge in chlorine leads to a smaller radius for chlorine. 1 mark

ii. Period numbers in the table correspond to the number of occupied electron shells in atoms of the elements. 1 mark

Transition metals correspond to the filling of d subshells. 1 mark

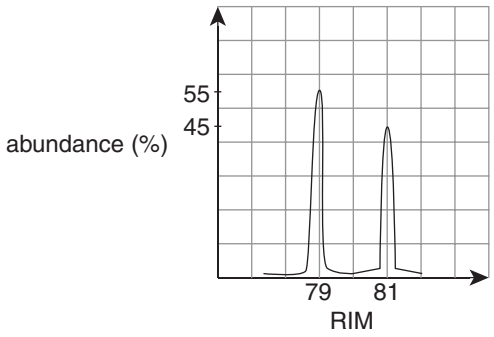
The first d subshell (3d) fills only after the 4s subshell is filled. Thus transition metals do not occur until the fourth period of the table. 1 mark

c. calculation of peak heights (relative abundance of each isotope)

$\text{RAM} = \Sigma(\text{RIM} \times \text{abundance fraction})$

$\therefore 79.9 = \frac{79x + 81(100 - x)}{100}$

$\therefore x = 55\%$ 1 mark



2 marks

Total 12 marks

Question 3

a.

ethanol (CH_3CH_2OH)	(I) II III (IV) V VI
sodium hydroxide (NaOH)	I (II) (III) IV (V) (VI)
graphite (C)	I II (III) IV V VI
methane (CH_4)	I II III (IV) V VI

4 marks

b. **i.** silicon dioxide 1 mark

ii. phosphine 1 mark

iii. carbon dioxide 1 mark

iv. potassium 1 mark

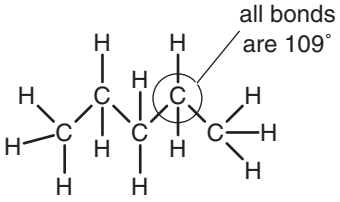
Total 8 marks

Question 4

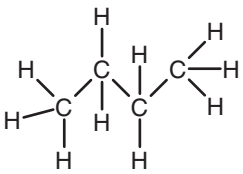
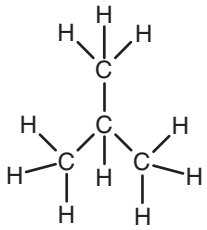
a. **i.** C_nH_{2n} 1 mark

ii. $$\%C = \frac{m(\text{carbon})}{m(\text{compound})} \times \frac{100}{1} = \frac{12n}{12n + 2n} \times \frac{100}{1} = \frac{12n}{14n} \times \frac{100}{1} = 85.7\%$$ 1 mark

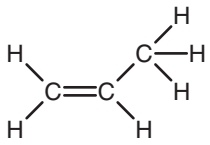
b. The carbon atoms form a zigzag 'line' due to the tetrahedral shape of the four atoms around each carbon atom. 1 mark



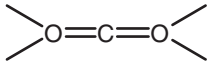
1 mark

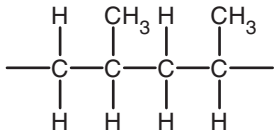
c. **i.**  OR 

1 mark

ii. 

1 mark

iii.  1 mark

iv. 

1 mark

d.

Structural feature	Polymer becomes harder	Polymer becomes elastic	Polymer has a lower melting temperature
highly branched monomers			✓
very long polymers	✓		
the presence of occasional cross-links between polymer chains		✓	

3 marks
Total 11 marks

Question 5

a. **i.** malleability or brittleness 1 mark

ii. metallic *(a lattice of cations in a sea of electrons)* 1 mark

iii. When the cations are disrupted by the applied force, the delocalised electrons move freely to 'fill' the spaces between the newly arranged cations. 1 mark

Since the bonding (electrostatic attractions) between cations and electrons remains, the metal is able to assume the new shape without shattering. 1 mark

b. **i.** conductivity of a molten substance 1 mark

ii. ionic *(a lattice of cations and anions)* 1 mark

iii. When the lattice is disrupted by heating the cations and anions are free to move. 1 mark

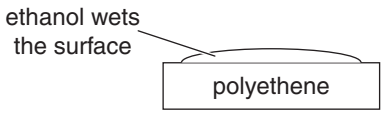
When the switch is closed, the current will flow (globe will glow) as the ions move in response to the applied potential difference. 1 mark

Total 8 marks

Question 6

a. Mercury has strong metallic bonding. It is difficult to disrupt this strong bonding to form a new unit area of surface. 1 mark

b. **i.**



1 mark

ii. The adhesive forces (dispersion forces) between the ethanol and polyethene surface are greater than the cohesive forces (hydrogen bonds) within the ethanol. 1 mark

The drop therefore flattens and ethanol wets the surface. 1 mark

c. **i.** Iron(III) oxide has a high surface energy and so will readily adsorb molecules of gases to its surface. 1 mark

ii. Nano-sized particles would have a very large surface area (for a given volume). 1 mark

The larger the surface area the more molecules can be adsorbed, and so the more effective is the catalyst. 1 mark

Total 7 marks