Neap

Trial Examination 2023

Suggested Solutions

QCE Chemistry Units 1&2

Paper 1

SECTION 1 – MULTIPLE CHOICE QUESTIONS

	A	B	C	D
1.	○	●	○	○
2.	○	●	○	○
3.	●	○	○	○
4.	○	○	●	○
5.	○	○	●	○
6.	○	●	○	○
7.	●	○	○	○
8.	○	○	○	●
9.	○	○	●	○
10.	○	●	○	○
11.	○	○	●	○
12.	●	○	○	○
13.	○	○	○	●
14.	○	○	●	○
15.	○	●	○	○
16.	○	○	○	●
17.	●	○	○	○
18.	○	○	●	○
19.	○	●	○	○
20.	○	○	●	○

QUESTION 1 B

In the notation $^{64}_{29}Cu$, 29 is the atomic number (indicating the number of protons), and 64 is the mass number (indicating the number of protons and neutrons, 29 protons + 35 neutrons = 64). Cu is the symbol for the element copper.

QUESTION 2 B

B is correct. Magnesium has 12 electrons; $1s^2 2s^2 2p^6 3s^2$ shows 12 electrons (2 + 2 + 6 + 2 = 12).

A is incorrect. This option shows 11 electrons.

C is incorrect. This option shows 16 electrons.

D is incorrect. This option shows 17 electrons.

QUESTION 3 A

A is correct. The iron(II) ion is Fe^{2+}, and the chloride ion is Cl^-. The combination of these two ions results in $FeCl_2$.

B, **C** and **D** are incorrect. These options have incorrect combinations that do not produce neutral compounds.

QUESTION 4 C

Effective nuclear charge is a net positive charge experienced by a valence electron (that is, attraction to the nucleus). Elements in the same group have a similar effective nuclear charge. Although the number of electron shells increases down a group, the number of protons in the nucleus minus the number of inner-shell electrons remains the same for each element. Therefore, the elements in a group have a constant amount of electron shielding that is proportional to their atomic size; thus, the valence electrons experience the same attraction to the nucleus.

Moving across a period, nuclear charge increases because a proton is added to each element moving from left to right (and thus a valence electron is also added), but the number of inner-shell electrons remains the same. This means that the elements in a period each have the same amount of shielding, but the valence electrons experience more attraction to the nucleus as there are more protons in the nucleus.

QUESTION 5 C

C is correct. A covalent bond is the sharing of one or more pairs of electrons between two atoms. Chlorine (Cl) is a highly electronegative element. Two atoms of Cl will form a pair of electrons resulting in a covalent bond with equally shared electrons.

A, **B** and **D** are incorrect. These pairs of elements will form ionic bonds as follows.

- The iron(II) ion (Fe^{2+}) will have an electrostatic attraction to the oxygen ion (O^{2-}) and form iron(II) oxide (FeO).
- The sodium ion (Na^+) will have an electrostatic attraction to the chloride ion (Cl^-) and form sodium chloride (NaCl).
- The magnesium ion (Mg^{2+}) will have an electrostatic attraction to two chloride ions (Cl^-) and form magnesium chloride ($MgCl_2$).

QUESTION 6 B

The relative atomic masses of the elements are N = 14.01 and O = 16.00.

$$M\left(NO_2\right) = 14.01 + (2 \times 16.00)$$
$$= 46.01$$
$$n\left(NO_2\right) = \frac{m}{M}$$
$$= \frac{22}{46.01}$$
$$= 0.47816 \text{ mol}$$
$$\text{number of molecules} = 0.47816 \times \left(6.02 \times 10^{23}\right)$$
$$= 2.879 \times 10^{23} \text{ molecules}$$

QUESTION 7 A

The empirical formula is the simplest whole number formula of a compound. The empirical formula of glucose is found by dividing the whole number formula, $C_6H_{12}O_6$, by 6. This gives the empirical formula of CH_2O.

QUESTION 8 D

The equation in the question is the reverse and double the original equation. Therefore, to determine the enthalpy change (ΔH) for the reaction in the question, the ΔH of the original equation, –890 kJ mol^{-1}, needs to be changed to a positive number (+890) and doubled (+890 × 2 = +1780 kJ mol^{-1}).

QUESTION 9 C

The electron pairs in the four single covalent bonds repel each other, leading to a perfect tetrahedral shape with bond angles of 109°; therefore, the molecule is symmetrical. The individual dipoles of the covalent bonds cancel each other out, and so the molecule does not have a net dipole.

QUESTION 10 B

B is correct. In paper chromatography and thin layer chromatography, the solvent is the mobile phase, which moves through the stationary phase.

A is incorrect. Adsorption, not desorption, is the attraction of one substance to the surface of another.

C is incorrect. Desorption, not adsorption, is the breaking of the attraction between a substance and the surface to which the substance is adsorbed.

D is incorrect. The components of a mixture undergo adsorption, not desorption, to the stationary phase.

QUESTION 11 C

C is correct. Butane is more compact and longer than methylpropane. This means that its molecules can be closer together compared to molecules of methylpropane. As a result, more energy is required to break the dispersion forces between butane molecules, which explains butane's higher boiling point.

A is incorrect. Butane and methylpropane both have four carbon atoms in their molecules.

B is incorrect. Methylpropane is a branched molecule, so it is less compact than butane.

D is incorrect. Methylpropane molecules take up more space than butane molecules; however, they have weaker dispersion forces because they cannot be as close together as butane molecules.

QUESTION 12 A

A is correct. Sample X has separated into four components, whereas sample Y contains one component, and sample Z has separated into two components.

B is incorrect. Samples X and Z both contain component I, but only sample X contains component IV.

C is incorrect. Sample Y contains component IV only.

D is incorrect. Sample Z contains components I and III only.

QUESTION 13 D

D is correct and **C** is incorrect. The graph shows the relationship between the volume of gas (V, vertical y-axis) and temperature (T, horizontal x-axis). As the graph shows a consistent, linear increase, it can be determined that the volume of gas increased proportionally to the increasing temperature.

A and **B** are incorrect. The graph does not present information related to pressure.

QUESTION 14 C

C is correct and **D** is incorrect. A catalyst provides a new reaction pathway by lowering the activation energy (E_a), thus allowing a reaction to occur more quickly.

A is incorrect. A catalyst does not take part in a reaction.

B is incorrect. E_a is never zero.

QUESTION 15 B

B is correct. The reaction between hydrochloric acid (HCl) and calcium carbonate ($CaCO_3$) produces the salt, calcium chloride, ($CaCl_2$), water (H_2O) and carbon dioxide (CO_2).

A is incorrect. This option is unbalanced and does not show CO_2 as a product.

C is incorrect. This option is unbalanced.

D is incorrect. This option shows the reaction of nitric acid (HNO_3) with $CaCO_3$.

QUESTION 16 D

D is correct. Silver chloride (AgCl) is the insoluble precipitate as indicated by its solid state, '(s)'. All other reactants and products are soluble.

A is incorrect. The sodium nitrate formed ($NaNO_3$) is soluble as indicated by its aqueous state, '(aq)'.

B is incorrect. The chloride ion (Cl^-) participates in the ionic reaction to form the precipitate according to the following equation.

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

C is incorrect. The sodium ion (Na^+) is not part of the AgCl precipitate; it forms part of $NaNO_3$.

QUESTION 17 A

A is correct. This balanced equation represents the combustion reaction of pentane (C_5H_{12}) with oxygen (O_2) to produce carbon dioxide (CO_2) and water (H_2O).

B is incorrect. This balanced equation represents the reaction between the base sodium hydroxide (NaOH) and dilute hydrochloric acid (HCl) to produce the salt, sodium chloride (NaCl) and H_2O.

C is incorrect. This balanced equation represents the reaction between dilute nitric acid (HNO_3) and sodium carbonate (Na_2CO_3) to produce sodium nitrate ($NaNO_3$), CO_2 and H_2O.

D is incorrect. This balanced equation represents the precipitation reaction between iron(III) nitrate ($Fe(NO_3)_3$) and sodium sulfide (Na_2S) to produce the precipitate, iron(III) sulfide (Fe_2S_3), and $NaNO_3$.

QUESTION 18 C

1 ppm = 1 mg kg^{-1} = 1 mg L^{-1}

$V = 2$ L

$m(\text{Mg}) = 0.050$ g = 50 mg

$$c(\text{Mg}) = \frac{50}{2.0}$$
$$= 25 \text{ mg L}^{-1}$$
$$= 25 \text{ ppm}$$

QUESTION 19 B

B is correct.

$V_1 = 50$ mL, $c_1 = 1.2$ M

$V_2 = 50 + 15 = 65$ mL, $c_2 = ?$

$$c_1V_1 = c_2V_2$$
$$\frac{1.2 \times 50}{1000} = \frac{c_2 \times 65}{1000}$$
$$c_2 = \frac{1.2 \times 50 \times 1000}{65 \times 1000}$$
$$= 0.92 \text{ M}$$

A is incorrect. This option uses 25 mL as V_1.

C is incorrect. This option uses 36 mL as V_2.

D is incorrect. This option uses 15 mL as V_2.

QUESTION 20 C

C is correct, and **A** and **B** are incorrect. Over time, the reaction rate decreases. The rate is fast at the beginning (the gradient of the curve is steep) and gradually slows down (the curve flattens).

D is incorrect. The rate of reaction decreases regardless of the amount of magnesium (Mg) present and the acid concentration; this is because the amount of products formed depends on the amount of reactants present.

SECTION 2

QUESTION 21 (2 marks)

$$M\left(C_{21}H_{30}O_2\right) = (21\times12.01)+(30\times1.01)+(2\times16.00)$$
$$= 252.21+30.30+32.00$$
$$= 314.51 \text{ g mol}^{-1}$$

[2 marks]
1 mark for identifying the relative atomic masses.
1 mark for determining the molar mass.

QUESTION 22 (3 marks)

a) Reading from the graph:

$$\Delta H = 0-25$$
$$= -25 \text{ kJ mol}^{-1}$$

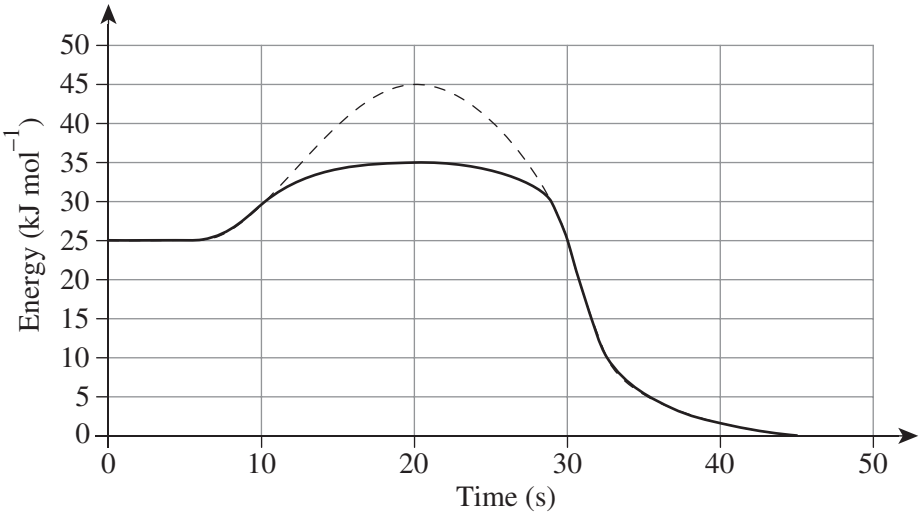
[1 mark]
1 mark for determining the enthalpy change.

b) Reading from the graph:

$$E_a = 45-25$$
$$= 20 \text{ kJ mol}^{-1}$$

[1 mark]
1 mark for determining the activation energy.

c) *For example:*



[1 mark]
1 mark for sketching the energy profile.
Note: The dotted line shows the original curve; the solid line shows the student's response. The student's response must show a lower E_a than the original curve.

QUESTION 23 (5 marks)

a) **Pair of atoms:** ${}^{12}_{6}\text{B}$ and ${}^{14}_{6}\text{F}$

Element: carbon

[2 marks]
1 mark for identifying the pair of atoms (same atomic number).
1 mark for naming the element.

b) **Atom:** ${}^{35}_{17}\text{I}$

Element: chlorine

[2 marks]
1 mark for identifying the atom.
1 mark for naming the element (atomic number of 17).

c) ${}^{11}_{5}\text{G}$

[1 mark]
1 mark for identifying the atom (atomic number of 5 indicates five electrons).

QUESTION 24 (4 marks)

There are five isotopes of zirconium (Zr), each with a different abundance.

Considering if there were 100 atoms:

$$\text{relative atomic mass} = \frac{\text{relative isotopic mass} \times \text{abundance (\%)}}{100} + \ldots$$

$$= \frac{(51.5 \times 90) + (11.2 \times 91) + (17.1 \times 92) + (17.4 \times 94) + (2.80 \times 96)}{100}$$

$$= 91.318$$

$$= 91.32$$

[4 marks]
1 mark for identifying that all five isotopes must be considered. Note: This may be implied by subsequent working.
1 mark for identifying the correct equation. Note: This may be implied by subsequent working.
1 mark for substituting into the equation.
1 mark for calculating the relative atomic mass.

QUESTION 25 (6 marks)

The compounds have similar molecular masses, so the strengths of their dispersion forces are similar. Butane is non-polar so the only intermolecular forces present between its molecules are dispersion forces, and it therefore has the lowest boiling point. Methoxyethane is polar, which means that, in addition to dispersion forces, there are dipole–dipole attractions between its molecules. Dipole–dipole attractions are stronger than dispersion forces, resulting in methoxyethane having a higher boiling point than butane. Propanol is polar and has a highly electronegative oxygen atom attached to a hydrogen atom, which means that the molecule can form hydrogen bonds. Propanol therefore has dispersion forces and hydrogen bonding between its molecules. Hydrogen bonding is the strongest intermolecular force, meaning that propanol has the highest boiling point of the three compounds.

[6 marks]

1 mark for identifying that butane is non-polar and identifying its intermolecular forces.
1 mark for explaining the effect of butane's intermolecular forces on its boiling point.
1 mark for identifying that methoxyethane is polar and identifying its intermolecular forces.
1 mark for explaining the effect of methoxyethane's intermolecular forces on its boiling point.
1 mark for identifying that propanol is polar and identifying its intermolecular forces.
1 mark for explaining the effect of propanol's intermolecular forces on its boiling point.

QUESTION 26 (4 marks)

Substance	Classification
A	ionic
B	metallic
C	covalent molecular
D	covalent molecular
E	covalent network
F	metallic

a) B and F

Both substances conduct electricity in solid and liquid states. Ionic and covalent substances do not do this.

[2 marks]

1 mark for identifying B and F.
1 mark for explaining in terms of the substances' electrical conductivity.

b) All three are covalent substances. C and D are covalent molecular, but E is a covalent network. Substance E has much higher melting and boiling points because it has many covalent bonds that need to be broken.

[2 marks]

1 mark for deducing states for all three substances.
1 mark for explaining why substance E has higher melting and boiling points in terms of covalent molecular and network structures.

QUESTION 27 (6 marks)

a) Calculating the amount of iron(III) nitrate ($Fe(NO_3)_3$) and sodium hydroxide (NaOH) gives:

$$n\left(\text{Fe}\left(\text{NO}_3\right)_3\right) = c \times V$$
$$= 0.1 \times \frac{20}{1000}$$
$$= 0.002 \text{ mol}$$

$$n(\text{NaOH}) = c \times V$$
$$= 0.1 \times \frac{20}{1000}$$
$$= 0.002 \text{ mol}$$

From the equation, the ratio of moles of $Fe(NO_3)_3$ to NaOH is 1 : 3. Therefore, the $Fe(NO_3)_3$ will not be used up and NaOH is the limiting reagent.

Determining the amount of iron(III) hydroxide ($Fe(OH)_3$) formed gives:

$$n\left(\text{Fe}\left(\text{NO}_3\right)_3 \text{ reacted}\right) = \frac{0.002}{3}$$
$$= 0.0006 \text{ mol}$$

Therefore, $n\left(\text{Fe(OH)}_3\right) = 0.0006$ mol.

Calculating the molar mass of $Fe(OH)_3$ gives:

$$M\left(\text{Fe(OH)}_3\right) = 55.85 + (3 \times 16.00) + (3 \times 1.01)$$
$$= 55.85 + 48.00 + 3.03$$
$$= 106.88$$

Calculating the mass of $Fe(OH)_3$ formed gives:

$$m\left(\text{Fe(OH)}_3\right) = n \times M$$
$$= 0.0006 \times 106.88$$
$$= 0.0713$$
$$= 0.07 \text{ g}$$

[4 marks]
1 mark for calculating the amount of $Fe(NO_3)_3$ and NaOH.
1 mark for determining the amount of precipitate ($(Fe(OH)_3$) formed.
1 mark for calculating the molar mass of $Fe(OH)_3$.
1 mark for calculating the mass of $Fe(OH)_3$ formed.

b) $$\text{percentage yield (\%)} = \frac{\text{experimental yield}}{\text{theoretical yield}} \times 100$$
$$= \frac{0.047 \times 100}{0.07}$$
$$= 67.1429$$
$$= 67.14\%$$

[2 marks]
1 mark for substituting into the formula.
1 mark for determining the percentage yield.