Trial Examination 2006

# VCE Chemistry Unit 4

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 |

**Question 1** **C**

There is a limited number of radioactive atoms present in the Earth's crust. The other sources listed are renewable.

**Question 2** **D**

Isotopes have the same number of protons (atomic number), but different numbers of neutrons (different mass number), ∴ not B or C. Isotopes have different densities, due to their different masses, ∴ not A or B. Chemical reactivity is determined by electron configuration. This is the same for isotopes.

**Question 3** **C**

For every 2 mol of nitrogen produced, 3 mol of oxygen react. Hence the rate of use of oxygen will be $\frac{3}{2} \times 0.40 = 0.60$.

**Question 4** **B**

The product is more stable than the reactants, and so the reaction will be exothermic (energy releasing). Recall that the $^{56}_{26}Fe$ nucleus is the most stable, with the highest binding energy per nucleon. $^{28}_{14}N$ has a higher binding energy per nucleon than $^{24}_{12}Mg$.

**Question 5** **B**

A fuel cell is not a primary cell. The reactants are continuously supplied and products removed. Primary cells have a fixed store of reactants. The statements in A, C and D are correct for fuel cells.

**Question 6** **A**

Reaction IV represents respiration, an exothermic process. The oxidation number of C in $C_6H_{12}O_6$ is 0, while in $CO_2$ it is +4. An increase in oxidation number indicates an oxidation reaction.

**Question 7** **A**

Reaction II is the condensation polymerisation of glucose to form starch, ∴ A or B. The synthesis of polymers is an endothermic process, ∴ A.

**Question 8** **B**

There is a decreasing trend in these ionisation energies, hence it must be elements down a group (ionisation energy increases across a period, and is relatively constant for transition metals). The ionisation energy of oxygen is less than that of fluorine, hence element V cannot be fluorine ∴ not C.

**Question 9** **B**

Manganese is element number 25. The manganese(II) ion must therefore have 23 electrons, ∴ B or C. Electrons are lost from the 4s sub-shell before the 3d sub-shell, ∴ B.

**Question 10** **A**

Metal Y reacts with the $X^{2+}$ ion, hence $X^{2+}$ is a stronger oxidant than $Y^{2+}$, and Y is a stronger reductant than X. Water does not react with metal X, hence $X^{2+}$ is a stronger oxidant than water, ∴ not D. The nitrate ion is not a reductant, ∴ not B.

**Question 11 D**

Y reacts to produce $Y^{2+}$, an oxidation reaction. Hence Y is the anode. Electrons are released spontaneously at this electrode, hence it is negatively charged.

**Question 12 D**

Electrons travel from Y to X. Cations will flow into the $X^{2+}/X$ half-cell to balance the accumulating negative charge entering the cell.

**Question 13 C**

Period 4 includes the 4s, 3d and 4p sub-shells.

**Question 14 A**

Bile contains surfactants which emulsify the fats, allowing dispersal of the fat in the aqueous surroundings. The process is physical, not chemical.

**Question 15 D**

$Na^+$ is smaller than Na, ∴ not A. Atomic radii decrease across a period, ∴ not B. In C, the four species listed have 10 electrons. Their nuclear charges are decreasing, hence their radii will show an increasing trend. Na is larger than Si, and C is larger than O (a periodic trend in radii). Si (2, 8, 4) is larger than C (2, 4), ∴ D.

**Question 16 B**

Lipids are insoluble in water, ∴ not A. Lipids are oxidised by oxygen, ∴ not C. Proteins require deamination, lipids and carbohydrates do not, ∴ not D. Lipids store approximately 37 kJ $g^{-1}$, compared with only 17 kJ $g^{-1}$ for carbohydrates.

**Question 17 C**

Many of the particles passed through with very little deflection (point Y), indicating that the atom is largely empty space. A few particles were deflected through large angles (point X), indicating a dense positive charge.

**Question 18 A**

Emission of an $\alpha$-particle (a helium nucleus) means a loss of 2 protons and 2 neutrons.

**Question 19 D**

$$n(e^-) = \frac{It}{F} = \frac{525 \times 7.5 \times 60 \times 60}{96\ 500}$$

$$Zn^{2+} + 2e^- \rightarrow Zn$$

$$n(Zn) = \frac{1}{2} n(e^-)$$

$$m(Zn) = n \times M = \frac{1}{2} \times \frac{525 \times 7.5 \times 60 \times 60}{96\ 500} \times 65.4 = 4803 \text{ g} = 4.8 \text{ kg}$$

**Question 20 C**

Water is a stronger oxidant than the aluminium ion, so water is reduced rather than the aluminium ion. Electrolysis of an aqueous solution of aluminium ion would therefore produce hydrogen and hydroxide ions, not aluminium. Aluminium oxide does dissolve in acid to form aluminium ions and water, ∴ not B.

## SECTION B: SHORT-ANSWER QUESTIONS

### Question 1

**a. i.** Ionisation of atoms or molecules by bombardment with electrons to produce positively charged ions. 1 mark

**ii.** Acceleration of positively charged ions so that they enter part C as moving particles. 1 mark

**iii.** A magnetic field deflects ions based on their size and charge. 1 mark

**b.** $A_r = \Sigma(\text{relative isotopic mass} \times \text{abundance fraction})$

$= (14.003 \times 0.99633) + (15.001 \times 0.003670)$ 1 mark

$= 14.01$ 1 mark

Total 5 marks

### Question 2

**a. i.** Calibration factor (c.f.) $= \dfrac{E}{\Delta T} = \dfrac{1440}{(19.55 - 17.97)} = \dfrac{1440}{1.58} = 911 \text{ J°C}^{-1}$ 1 mark

**ii.** $E = \text{c.f.} \times \Delta T = 911.4 \times 5.17 = 4712 \text{ J}$ 1 mark

Energy content $= \dfrac{E}{m} = \dfrac{4712}{0.142} = 33\ 183 \text{ J} = 33.2 \text{ kJ g}^{-1}$ 1 mark

**iii.** $E(\text{apple}) = 1.9 \times m(\text{apple}) = 1.9 \times 0.23 \times 0.142 = 0.0621 \text{ kJ}$ 1 mark

$\%(\text{energy}) = \dfrac{E(\text{apple})}{E(\text{total})} = \dfrac{0.0621}{4.712} \times 100 = 1.3\%$ 1 mark

**iv.** Crushing ensures a large surface area and hence a faster, more complete reaction. 1 mark

**b. i.** To stabilise the oil and water components of the mixture. 1 mark

**ii.** Emulsifiers have a hydrophobic (non-polar) section (usually a long hydrocarbon chain) and a hydrophilic (polar) section. 1 mark

**c.** Glucose and fructose. 1 mark

Total 9 marks

### Question 3

**a. i.** Fission involves splitting of a larger nucleus into smaller nuclei. e.g.

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{92}_{36}\text{Kr} + {}^{141}_{56}\text{Ba} + 3\,{}^{1}_{0}\text{n}$$ 1 mark

Fusion involves the joining of smaller nuclei to form a larger nucleus. e.g.

$$4\,{}^{1}_{1}\text{H} \rightarrow {}^{4}_{2}\text{He} + 2\,{}^{0}_{1}\text{e}$$ 1 mark

**ii.** Nitrogen fixation is the conversion of atmospheric molecular nitrogen into soluble compounds which can be absorbed by plants. 1 mark

Denitrification is the conversion of $NO_3^-$ ions into molecular nitrogen, $N_2$. It returns nitrogen to the atmosphere. 1 mark

**b. i.** Moving down a group the outer-shell electrons are further from the nucleus and so are less strongly attracted (core charge is constant down the group). 1 mark

Oxidant strength is the ability to attract electrons, hence it decreases down the group. 1 mark

**ii.** First row transition metals have electrons in the 4s and 3d orbitals. The energies of the occupied 4s and 3d orbitals are similar. 1 mark

Electrons can therefore be readily lost from both, resulting in different charges on the transition metal ions. 1 mark

**iii.** Prior to the 1800s not enough elements were known to enable patterns in properties to be established.

OR

Accurate values for the relative atomic masses were not known prior to the 1800s. 1 mark

Total 9 marks

**Question 4**

**a.** $n(\text{HI}) = \dfrac{m}{M} = \dfrac{85.0}{127.9} = 0.665 \text{ mol}$ 1 mark

2 mol of HI absorbs 25.9 kJ

0.665 mol of HI absorbs $x$ kJ

$\therefore x = \dfrac{0.665}{2} \times 25.9 = 8.61 \text{ kJ}$ 1 mark

**b.** $\Delta H = -25.9 \times 2 = -51.8 \text{ kJ mol}^{-1}$ 1 mark

*This is a reverse equation, ∴ ΔH is negative. This is a doubled equation, ∴ ΔH is doubled.*

**c.** activation energy = 186 – 25.9 = 160 kJ $\text{mol}^{-1}$ 1 mark

Total 4 marks

**Question 5**

**a.** Stearic acid has a saturated hydrocarbon chain. These chains are relatively linear and so pack together neatly. The unsaturated chains in oleic acid and linoleic acids mean that chains are not linear and do not pack together neatly. 1 mark

This results in weaker dispersion forces between chains, and hence lower melting points. 1 mark

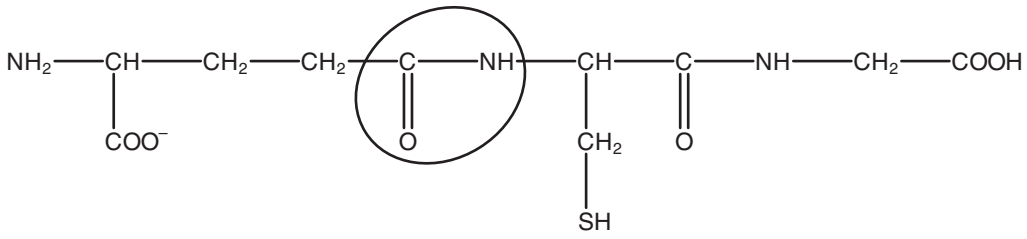
**b.** It must be obtained through the diet as it cannot be synthesised in the body. 1 mark

**c.** $2C_{18}H_{34}O_2(l) + 51O_2(g) \rightarrow 36CO_2(g) + 34H_2O(l)$ 1 mark

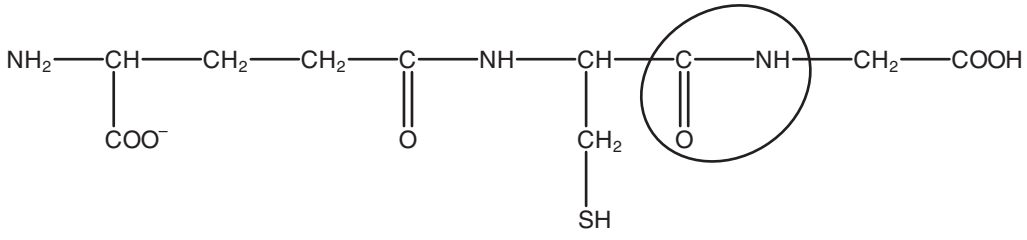
Total 4 marks

**Question 6**

**a.** **i.**




OR




$\frac{1}{2}$ mark

**ii.** $H_2O$ $\frac{1}{2}$ mark

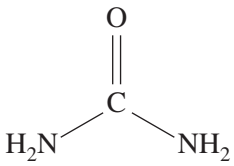
**b.** The peptide link occurs through the –COOH side group, rather than the more usual connection through the –COOH group on the $\alpha$-carbon atom. 1 mark

**c.** **i.** It is able to donate two protons as it contains two acidic –COOH groups. 1 mark

**ii.** It is able to act as an acid (–COOH) by donating a proton, and as a base ($-NH_2$) by accepting a proton. 1 mark

**d.** The complex, three-dimensional shape of the protein molecule. 1 mark

**e.** **i.**




1 mark

**ii.** $CO_2$ and $H_2O$ 1 mark

Total 7 marks

**Question 7**

**a.** Positive. 1 mark
Forced oxidation is to occur at the 'blister' copper surface. This means that the power supply must withdraw electrons, and so must be positively charged. 1 mark

**b.** **i.** Oxidation of copper atoms. $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ 1 mark

**ii.** Oxidation of iron atoms. $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$ 1 mark

**iii.** They will not be oxidised as they are weaker reductants than copper. They fall to the bottom of the cell. 1 mark

**c.** **i.** $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ 1 mark

**ii.** No change. The copper ion is still the best oxidant and so will be reduced at the graphite electrode. 1 mark

*The more expensive copper electrode is used to avoid the problem of removing the deposited copper from a graphite electrode.*

Total 7 marks