Neap:

Trial Examination 2007

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**

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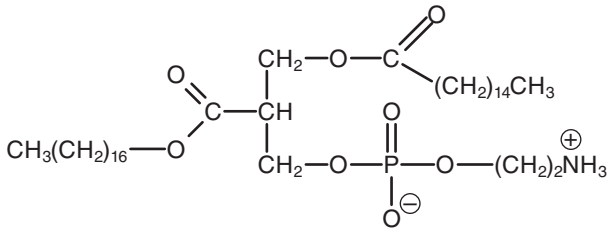
Question 1 D

The molecule shown has the structure of an emulsifier – a substance which prevents the separation of oil and water layers. The molecule has polar and non-polar sections – this is typical of surfactants (emulsifiers).



Question 2 C

Metal oxides such as Na_2O form basic solutions when they react with water.

$$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$$

Non-metal oxides such as P_2O_5 form acidic solutions when they react with water.

$$P_2O_5(s) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$$

While Al_2O_3 is amphoteric (both acidic and basic) it is insoluble in water and so will not produce an acidic solution.

Question 3 B

A – This represents aerobic respiration. This is an exothermic process.

B – This represents synthesis of starch by condensation polymerisation. This is an endothermic process.

C – This represents fermentation (anaerobic respiration). This is an exothermic process.

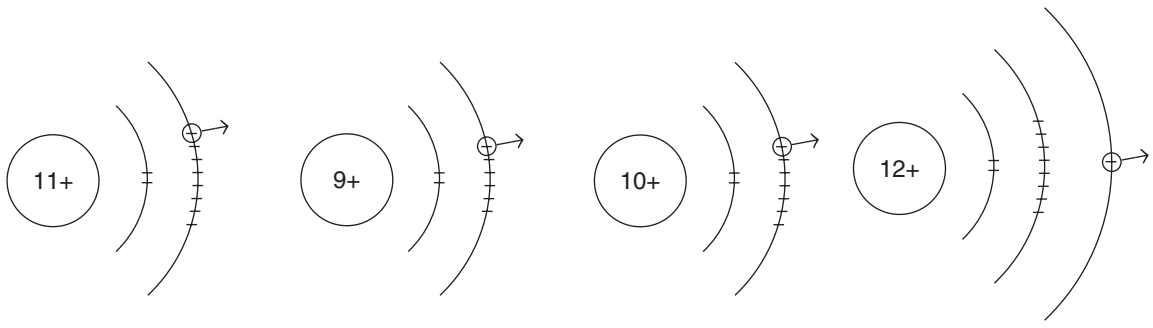
D – This represents the dehydration of glucose. This is an exothermic process.

Question 4 B

Over three-quarters of Australia's electricity is produced by coal-fired power stations. Hydroelectric power stations supply around 10% of Australia's electricity. Less than 1% of Australia's total energy needs are provided by solar energy.

Question 5 A

Consider the sketches below that show the removal of the second most loosely bound electron for each atom. Consider the effective nuclear charge (ENC) felt by the electron and its distance from the nucleus.



Na	F	Ne	Mg
2nd shell	2nd shell	2nd shell	3rd shell electron
ENC = +9	ENC = +7	ENC = +8	ENC = +2

Question 6 B

Humans lack the enzyme necessary for the hydrolysis of the ether linkage in cellulose. Cellulose is not soluble in water, but this does not account for its inability to be broken down (therefore not **A**). Acidic conditions are found in the stomach (so the answer cannot be **C**). The breakdown of cellulose and subsequent combustion of glucose is an exothermic process (therefore not **D**).

Question 7 D

Bohr based his energy levels/shells model on the idea that electrons moved between specific energy levels to emit the observed colours of light in the emission spectrum. Rutherford's gold foil experiment led to the nuclear model (so not **A**). Chadwick confirmed the existence of the neutron (so not **B**). Knowledge of the number of electrons per shell comes partly from the study of ionisation energies (so not **C**).

Question 8 A

Relevant equations for the Hall–Heroult cell are

$$\text{cathode } Al^{3+}(l) + 3e^- \rightarrow Al(l)$$

$$\text{anode } C(s) + 2O^{2-}(l) \rightarrow CO_2(g) + 4e^-$$

Question 9 A

Ag^+ is the strongest oxidant, hence it is reduced at the cathode (therefore not answer **C**).

$$Ag^+(aq) + e^- \rightarrow Ag(s)$$

Zn is oxidised at the anode, which carries a negative charge due to the electrons being generated there (therefore not answer **D**).

$$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$$

Electron flow is therefore from Zn to Ag (therefore not answer **B**). Positive ions flow into the Ag^+/Ag half-cell to balance the accumulating negative charge.

Question 10 B

Predictions using the electrochemical series are based on standard conditions (1.0 M, 25°C, 1.0 atm). The concentration of the solutions used is not specified, so may well have been other than 1.0 M, resulting in a cell voltage different from that predicted. 25°C is standard temperature, so statement **C** is not a valid explanation. $NaNO_3$ and KNO_3 would behave similarly in the salt bridge (so not answer **D**). Incorrectly connecting the electrodes would result in a negative reading on the voltmeter, not an altered numeric value (so not answer **A**).

Question 11 C

Negatively charged ions will be attracted to the positive electrode. At the positive electrode a forced oxidation occurs. The nitrate ion is not a reductant and therefore does not undergo oxidation.

Question 12 C

When nucleons combine to form a nucleus, energy is released. The source of this energy is the mass loss which occurs when the nucleons combine to form a stable nucleus. Thus the mass of the nucleus is slightly smaller than the combined masses of the nucleons.

Question 13 D

Cf is less stable than Cm (it has a lower binding energy per nucleon), hence energy will be absorbed (so answer **B** or **D**). An alpha particle is a helium nucleus, ^4_2He.

Question 14 C

2 mol of C_6H_5COOH = 244.0 g releases 6454 kJ

$\therefore 1.793$ g releases x kJ

$\therefore x = 47.43$ kJ

$$\text{CF} = \frac{E}{\Delta T} = \frac{47.43}{17.1} = 2.77 \text{ kJ } ^\circ\text{C}^{-1}$$

Question 15 A

Reduction occurs at the cathode (hence answer **A** or **B**). The cell uses an alkaline electrolyte, hence H^+ will not be present (therefore answer **A**, not **B**).

Question 16 D

During recharging, the cell reaction is reversed. At the positive electrode, electrons are withdrawn by the power supply. A forced oxidation occurs to replace these withdrawn electrons. Oxidation produces NiO(OH) and H_2O (the reverse of the reduction reaction in Question 15).

Question 17 A

reverse equation 2

$$18H_2O(l) + 16CO_2(g) \rightarrow 2C_8H_{18}(l) + 25O_2(g) \quad \Delta H = +10\,900 \text{ kJ mol}^{-1}$$

add equation 1 to give

$$18H_2O(l) \rightarrow 18H_2O(g) \quad \Delta H = +10\,900 - 10\,108 = +792 \text{ kJ mol}^{-1}$$

Therefore

$$H_2O(l) \rightarrow H_2O(g) \quad \Delta H = +\left(\frac{792}{18}\right) = +44 \text{ kJ mol}^{-1}$$

Question 18 B

Plants only absorb NO_3^- and NH_4^+ ions directly.

Question 19 C

The oxidation states of nitrogen in each species are shown in the table below.

Species	N_2	NO	NO_2	NO_2^-	NO_3^-	NH_4^+
Oxidation state of nitrogen	0	+2	+4	+3	+5	–3

Only NH_4^+ can be oxidised to produce any of the other species as the nitrogen has the lowest oxidation state in this species.

Question 20 D

Starch is insoluble in water as it is a very large molecule. Disaccharides are soluble because they are much smaller, and water can hydrogen bond with the polar hydroxy functional groups in disaccharides. It is true that starch is made up of only glucose units, but maltose is also made up of only glucose units, so **A** is incorrect. Both disaccharides and starch can be converted to glucose, and any excess glucose is stored as glycogen regardless of the original carbohydrate consumed (therefore **C** is incorrect). Starch can be digested because humans have the enzyme that allows its digestion (therefore **B** is incorrect).

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. $E = m \times c \times \Delta T = 20.00 \times 4.18 \times (77.90 - 18.50) = 4966 \text{ J} = 4.97 \text{ kJ}$ 1 mark

b. $\text{energy} = \dfrac{4966}{(2.050 - 0.860)} = 4173 \text{ J g}^{-1} = 4.17 \times 10^3 \text{ J g}^{-1}$ 1 mark

c. energy (via experiment) = 4.173 kJ g^{-1}

energy (via food label) = 24.07 kJ g^{-1}

$\%\text{ transfer} = \left(\dfrac{4.173}{24.07}\right) \times 100 = 17.3\%$ 1 mark

d. Either one of

- insulation of test tube to ensure no loss of heat from the water;
- insulation of the heat from the cashew to direct it to the test tube and prevent heat escaping to the environment.

1 mark

Total 4 marks

Question 2

a. **i.** Calcium and potassium atoms both have four occupied electron shells. The nuclear charge for calcium (+20) is greater than that of potassium (+19). 1 mark

Greater nuclear charge leads to a stronger attraction for the outer-shell electrons. This stronger attraction decreases the atom's radius. 1 mark

ii. The smaller size of the manganese atoms (together with the larger nuclear charge) means that they pack more closely together than those of calcium. 1 mark

This close packing leads to a stronger metallic bond and so higher melting and boiling points. 1 mark

b. **i.** $ls^2 2s^2 2p^6 3s^2 3p^6 3d^5$ 1 mark

ii. +7 (in $KMnO_4$) 1 mark

c. **i.** The transition of electrons between the partially filled 3d orbitals in manganese ions requires the same amount of energy as that provided by visible light. 1 mark

Thus manganese solutions absorb certain wavelengths of light, giving rise to coloured solutions. 1 mark

ii. MnO_4^- is a strong oxidant. If the reductant Cl^- (from hydrochloric acid) is added, a redox reaction occurs. 1 mark

This results in reduction of MnO_4^- to Mn^{2+}, and oxidation of Cl^- to Cl_2. 1 mark

Total 10 marks

Question 3

a. **i.** Br 1 mark

ii. Ra 1 mark

iii. Tc 1 mark

iv. Cl 1 mark

b. **i.** CO_2 and H_2O 1 mark

ii. $C_4H_8N_2O_3$ $(C_2H_5NO_2 + C_2H_5NO_2 - H_2O)$ 1 mark

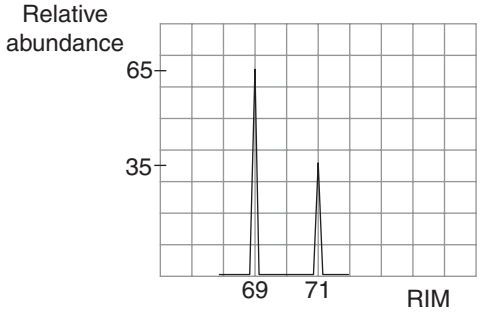
iii. Cl_2 1 mark

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

$\therefore 69.7 = 69x + 71(1 - x)$

$\therefore x = 0.65$

Therefore, the % of ^{69}Ga = 65, % of ^{71}Ga = 35 1 mark



1 mark

d. **i.** 2 mol CH_3OH = 64.0 g releases 1450 kJ

$\therefore$ 1.0 g releases x kJ

$\therefore$ 22.7 kJ g^{-1} 1 mark

ii. $CH_3OH(l) + H_2O(l) \rightarrow CO_2(g) + 6H^+(aq) + 6e^-$ 1 mark

Total 11 marks

Question 4

a. **i.** The oxidation reaction with O_2 from the air has not yet occurred. 1 mark

ii. The acidity of the lemon juice denatures the protein structure of the enzyme. The enzyme is no longer able to catalyse the reaction. 1 mark

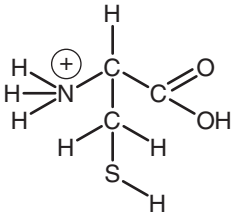
iii. Crushing increases the surface area of the apple, allowing faster rate of reaction. 1 mark

b. Ascorbic acid has several –OH groups. These polar groups allow ascorbic acid to be water soluble. It would therefore be unsuitable for use in a non-polar, oil-based spread. 1 mark

BHA is a largely non-polar molecule. It would be suitable for use in the non-polar, oil-based spread. 1 mark

c. **i.** The $-NH_2$ and –COOH functional groups are joined to the same carbon atom in the amino acid molecule. 1 mark

ii.



2 marks
1 mark for general structure
1 mark for NH_3^+
Total 8 marks

Question 5

a. $n(\text{Ag}) = \dfrac{m}{M} = \dfrac{6.20 \times 10^{-3}}{107.9} = 5.746 \times 10^{-5}$ mol 1 mark

$n(e^-) = n(\text{Ag}) = 5.746 \times 10^{-5}$ 1 mark

$t = \dfrac{n(e^-) \times F}{I} = \dfrac{(5.746 \times 10^{-5} \times 96\ 500)}{0.350} = 15.8$ s 1 mark

b. $n(\text{Au}) = \dfrac{m}{M} = \dfrac{5.66 \times 10^{-3}}{197.0} = 2.873 \times 10^{-5}$ mol 1 mark

$n(e^-) = 5.746 \times 10^{-5}$ mol (same conditions as part **a**)

$n(e^-) \div n(\text{Au}) = 5.746 \times 10^{-5} \div (2.873 \times 10^{-5}) = 2$

Therefore the gold ions in solution are Au^{2+}. 1 mark

c. Negative, because this is the cathode, so that the forced reduction of Au^{2+} ions occurs. 1 mark

Total 6 marks

Question 6

a. With a molecular formula of $C_{16}H_{31}$, the fatty acid chain is unsaturated. 1 mark

It has the general formula C_nH_{2n-1}, typical of a hydrocarbon containing one double carbon–carbon bond. 1 mark

b. **i.** ester 1 mark

ii. glycerol ($C_3H_8O_3$) 1 mark

c. Biodiesel is a renewable source. 1 mark

d. $2CH_3OOCC_{16}H_{31}(s) + 51O_2(g) \rightarrow 36CO_2(g) + 34H_2O(l)$ 1 mark

Total 6 marks