Neap

Trial Examination 2020

VCE Chemistry Unit 3

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

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

Question 1 D

Le Chatelier's principle (LCP) relates to equilibrium systems and the partial overcoming of changes made to an equilibrium system.

Question 2 C

Carbon monoxide (CO) poisoning will occur where there is limited clean air and even a very low concentration of carbon monoxide present. Typically, using fuels in a confined area will increase incomplete combustion and so increase the concentration of CO. **C** is the correct answer. Lawnmowers generate some CO but the wide, open spaces of a lawn are likely to prevent CO poisoning. **A** is incorrect. In the situations of **B** and **D**, almost no CO would be generated, so these alternatives are incorrect.

Question 3 C

CO poisoning illustrates competing equilibria because, in the formation of oxyhaemoglobin or carboxyhaemoglobin, the same pool of haemoglobin in the body is used. The K_c for the formation of carboxyhaemoglobin is thousands of times larger than the K_c for oxyhaemoglobin formation. Thus, low concentrations of CO can compete very successfully by forcing the removal of oxygen from oxyhaemoglobin so that carboxyhaemoglobin forms. Administering pure oxygen reverses this process, forcing the dissociation of carboxyhaemoglobin and making haemoglobin available for oxygen transport. CO is subsequently breathed out of the body.

Question 4 A

In a galvanic cell chemical energy is converted to electrical energy, but some energy is wasted as heat and so **B** and **D** are correct. Electrical energy is converted to chemical energy in an electrolytic cell and so **C** is also correct. Heat energy is not converted to electrical energy in either cell. **A** is the required answer.

Question 5 B

Only a secondary cell produces products that remain in contact with the electrodes so that it can be recharged using electrical energy. This does not happen in a primary cell. **A** is incorrect. Oxidation occurs at the anode or negative electrode in both cells during discharge. **D** is incorrect. The cathode is positive in both cells during discharge, but is negative during recharge in the secondary cell, and so **C** is not correct. Cell reactions are spontaneous redox reactions that would produce heat energy if the half-reactions were not separated from each other. **B** is the required answer.

Question 6 C

The porous separator allows ion movement through it and also prevents a short circuit by stopping any contact of the electrode plates. Statements I and III are correct. Electrons travel via the external circuit, not within the electrolyte. Statement II is incorrect.

Question 7 C

During discharge, the positive electrode of the battery is the site of reduction – that is, the consumption of electrons. During recharge, electrons must be removed from this electrode and the reaction reversed. The positive terminal of the power pack removes electrons and forces them onto the negative electrode of the battery. If only 12 V is used during recharge, the spontaneous forward reaction will be stopped but recharging will not occur. Therefore more than 12 V must be used.

Question 8 A

Oxidation occurs at the anode in an electrolytic cell. The two chemical species that can be oxidised are iodide ions and water. I^- ions are stronger reducing agents than water and so will be discharged more readily at the anode: $2I^-(aq) \rightarrow I_2(s) + 2e^-$.

Question 9 D

$$n(C_8H_{18}) = \frac{m}{M} = \frac{65.0}{114} \text{ mol}$$

$$n(CO_2) = 8 \times n(C_8H_{18})$$

$$V(CO_2) = \frac{nRT}{p} = \frac{8 \times 65.0 \times 8.31 \times 303}{114 \times 110} = 104 \text{ L}$$

Question 10 B

energy from combustion of ethanol = 2.0 × 29.6 = 59.2 kJ

$$\text{change in temperature} = \frac{E}{mc} = \frac{59\ 200}{500 \times 4.18} = 28.3°\text{C}$$

final temperature of the water = 20 + 28 = 48ºC

Question 11 A

$$Q = It = 35\ 000 \times 60 \times 60 = 1.26 \times 10^8 \text{ C}$$

$$n(e^-) = \frac{Q}{F} = \frac{1.26 \times 10^8}{96\ 500} = 1.30 \times 10^3 \text{ mol}$$

$$n(\text{Al}) = \frac{n(e^-)}{3} = \frac{1.30 \times 10^3}{3} = 435 \text{ mol}$$

$$m(\text{Al}) = n \times M = 435 \times 27.0 = 11\ 751 \text{ g} = 11.8 \text{ kg}$$

Question 12 B

In the hydrogen–oxygen fuel cell the two reactant gases do not react spontaneously at room temperature and so it is reasonable to assume that a catalyst is needed for the reaction to occur. Feature I is correct. Inert electrodes ensure that these do not need to be replaced and that only the reactant gases participate in the cell reaction. Feature II is correct. The gases must be in contact with the electrodes and the electrolyte and so porous electrodes will allow movement of gases from storage areas to the site of oxidation or reduction. Feature III is not present in the hydrogen–oxygen fuel cell. A large surface area enables a more rapid rate of reaction and so feature IV is likely to be present.

Question 13 D

From the electrochemical (EC) series it is evident that Cl_2 is a stronger oxidising agent than Sn^{4+} ions and so electrode Y is the anode, or negative electrode, where oxidation of Sn^{2+} occurs. **A** is incorrect and **D** is correct. Reduction of Cl_2 occurs at electrode X and so the chloride concentration increases. **B** is incorrect. Hydrogen gas could only form at electrode X if water was reduced there, but chlorine gas is a much stronger oxidising agent than water and so no gas will be produced. **C** is incorrect.

Question 14 **B**

The relevant reactions from the EC series are:

$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$ $E° = +0.77$ V

$Mn^{2+}(aq) + 2e^- \rightleftharpoons Mn(s)$ $E° = -1.18$ V

$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$ $E° = -2.37$ V

The reactions in both beakers are spontaneous redox reactions that will generate energy. Statement I is incorrect. The EC series does not indicate the rate at which reactions will occur and so statement II is also incorrect. The larger the difference in $E°$ values between two redox pairs, the more likely it is that the reaction will go to completion – that is, the reaction will have a large K_c. Thus, statement III is correct.

Question 15 **A**

Adding oxygen will move the equilibrium to the right to partially oppose the increase in reactant concentration. **C** and **D** are incorrect. Adding a reactant will decrease the value of the concentration fraction (products/reactants), and so the reaction moves to the right to restore/increase the fraction to the equilibrium constant value.

Question 16 **D**

The equilibrium constant for the reversed equation is the reciprocal of the constant for the forward reaction; that is, $\frac{1}{398} = 2.5 \times 10^{-3}$. The activation energy for the reverse reaction is 197 + 460 = 657.

Question 17 **B**

From the equation, 68 mol of greenhouse gases (34 mol of CO_2 and 34 mol of H_2O) are released for each 1.18×10^4 kJ produced.

$34 \times 44 = 1496$ g CO_2 and $34 \times 18 = 612$ g of H_2O per 1.18×10^4 kJ = 11.8 MJ.

x g CO_2 and y g of H_2O per 1.0 MJ

Solving gives $x = 127$ g and $y = 52$ g. Therefore total mass of greenhouse gases = 179 g.

Question 18 **A**

Metal R forming when metal Q is placed in R^{2+}solution shows that R^{2+} is a stronger oxidising agent than Q^{2+}. Metal P in Q^{2+} solution producing no reaction shows that P^{2+} is a stronger oxidising agent than Q^{2+}. Metal R in P^{2+} solution producing no reaction shows that R^{2+} is a stronger oxidising agent than P^{2+}. So the order of increasing oxidising strength is $Q^{2+} < P^{2+} < R^{2+}$.

Question 19 **D**

For a reaction to occur with a metal, the conjugate oxidising agent of the metal must be a weaker oxidising agent than H^+ ions according to the EC series. No information is given about the position of the conjugate oxidising agents relative to H^+ ions and so a prediction cannot be made about the likelihood of a reaction.

Question 20 C

Heating the sample will flatten the Maxwell–Boltzmann distribution curve and move the peak a little to the right. The position of the peak is indicative of the average kinetic energy of the particles. So **A**, **B** and **D** are incorrect. In a sealed sample of gas, the number of particles does not change with an increase in temperature. The total area under the curve is a measure of the number of particles in the sample. **C** is the required answer.

SECTION B

Question 1 (8 marks)

a. **i.** Oxygen in the air is a reactant in the reaction and would be used up without a current of air. 1 mark

By LCP, an increase in the amount of a reactant will move the position of equilibrium to the products, resulting in a greater yield of ZnO. 1 mark

ii. *For example:*

It is costly to purchase and store pure oxygen gas, and it is likely that an acceptable production of ZnO can be achieved more cheaply using air. 1 mark

b. $2C(s) + O_2(g) \rightarrow 2CO(g)$ 1 mark

c. **i.** negative cathode 1 mark

ii. $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$ 1 mark

iii. At the cathode, the strongest oxidising agent will be preferentially reduced. Zinc ions are stronger oxidising agents than water and so zinc will be formed rather than hydrogen gas. 1 mark

Water is a stronger oxidising agent than magnesium ions and so magnesium metal will only be formed if water is not present, as in a molten electrolyte. 1 mark

Question 2 (14 marks)

a. **i.** Heat is given out in the converter and recycled to the vessel with the initial reactants. 1 mark

As energy is given out in the reaction, it is an exothermic reaction. 1 mark

ii. In the equation, 4 mol of reactants give 2 mol of products. By LCP, increasing the pressure will change the position of equilibrium to the side with fewer mole of gases, and so more products will be generated. 1 mark

High pressure increases the rate of the reaction. 1 mark

iii. A high temperature ensures that more reactant particles have energies that are sufficient to overcome the activation energy barrier, resulting in a higher rate of reaction. 1 mark

A low temperature for an exothermic equilibrium reaction ensures that the forward reaction is favoured to produce a higher yield. 1 mark

The temperature conflict is resolved by using a moderate temperature, which produces an economically beneficial yield at an acceptable rate. 1 mark

b. **i.** $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ 1 mark

ii. A biofuel is produced from a recently living plant or animal product. Hydrogen gas generated from water does not satisfy this criterion. 1 mark

iii. A renewable fuel does not have a finite supply and can be produced repeatedly. It can be produced at a faster rate than it is used. Hydrogen gas produced from electrolysis of water satisfies this criterion. 1 mark

iv. $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ $\Delta H = -564 \text{ kJ mol}^{-1}$

OR

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H = -282 \text{ kJ mol}^{-1}$ 2 marks

1 mark for correct reactants and products with states.
1 mark for correct enthalpy change with units and correct sign.

c. *For example*:

- Hydrogen gas is explosive when mixed with air and so transporting liquid ammonia is safer.
- A greater amount of fuel per litre will be available if transported as a liquid rather than a gas.

2 marks

Question 3 (9 marks)

a. $n(\text{Fe}) = \frac{m}{M} = \frac{11.2}{55.8}$ mol 1 mark

$n(O_2) = \frac{3}{4} \times n(\text{Fe}) = 0.1505$ mol 1 mark

$V(O_2)$ at SLC = $n \times V_M = 0.1505 \times 24.8 = 3.73$ L 1 mark

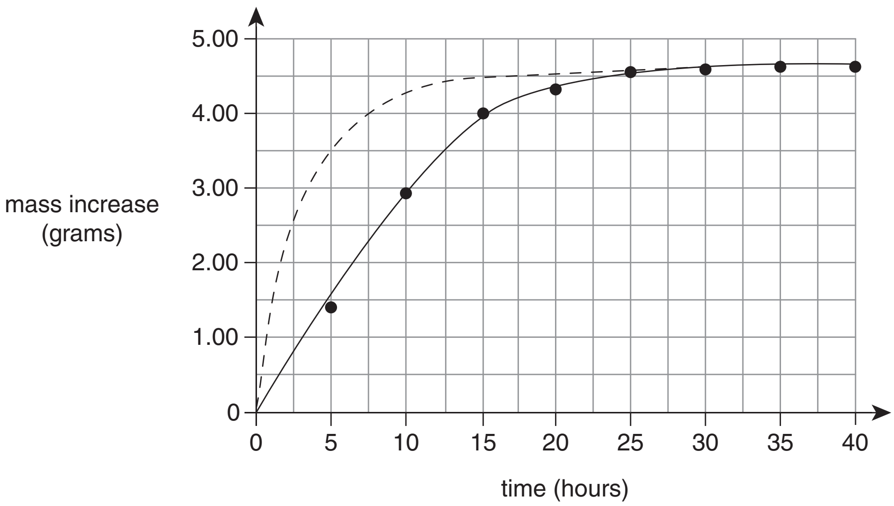
b. **i.** The rate of reaction is lower than in the earlier interval, as more of the iron has reacted and decreasing amounts are available to participate in the reaction. 1 mark

Thus, the frequency of collisions between Fe and O_2 decreases, resulting in a decreasing rate of reaction. 1 mark

ii. All of the iron has been converted to iron oxide and so the rate of reaction is zero. 1 mark

Without any reactant particles to collide, there can be no successful collisions and so the mass does not change in this interval. 1 mark

c.



2 marks

1 mark for steeper initial section of graph.
1 mark for earlier plateau but at same level.

Question 4 (9 marks)

a. **i.** There must be ions present in the liquid in the potato (because charge must be transferred for the galvanic cell to operate). 1 mark

ii. $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$ 1 mark

b. **i.** the porous pot 1 mark

ii. zinc ions ($Zn^{2+}(aq)$) 1 mark

iii. emf = $E°$ (oxidising agent) – $E°$ (reducing agent) = 0.34 – (–0.76) = 1.10 V 1 mark

iv. *For example:*

The standard electrode potentials were measured under a set of standard conditions. If the conditions of the cell vary from these standard conditions – for example, if the temperature is not 25°C – the actual emf will not match the expected emf. 1 mark

c. $m(\text{Zn}) = \frac{n}{M} = \frac{1.0}{65.4}$ mol

$n(\text{e}^-) = 2 \times n(\text{Zn}) = 2 \times \frac{1.0}{65.4} = 0.03058$ mol 1 mark

$Q = n(\text{e}^-) \times F = 0.03058 \times 96\,500 = 2951$ C 1 mark

$E = VQ = 0.85 \times 2951$ J = 2.5 kJ 1 mark

Question 5 (11 marks)

a. **i.** $K_c = \frac{[CH_3OH]}{[CO][H_2]^2}$ 1 mark

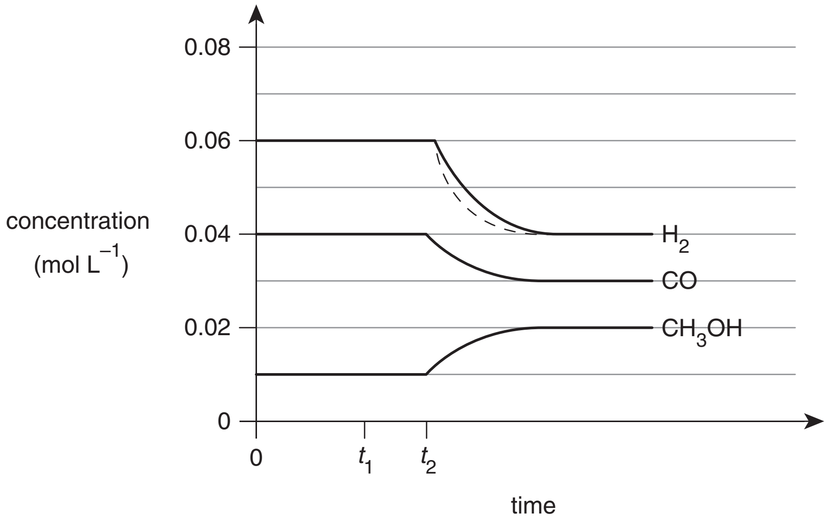
$= \frac{0.01}{(0.04)(0.06)^2}$

$= 69\ \text{M}^{-2} = 7 \times 10^1\ \text{M}^{-2}$ 1 mark

ii. The temperature was decreased and caused the reaction to move to the right. By LCP, removing heat from a reaction at equilibrium will be opposed by the reaction generating more heat and this was achieved by the reaction moving towards the products. 1 mark

The reaction is exothermic. 1 mark

iii.



2 marks

1 mark for a steeper decrease of concentration.
1 mark for earlier plateau but at the same value.

b. i. *For example*:

Boiling water to generate steam could cause severe burns for the experimenter and so precautions such as the use of heatproof gloves should be taken. 1 mark

ii. At each energy transformation some energy would be 'lost' as heat energy. Method I uses only one energy transformation (chemical to electrical), whereas method II uses several (chemical to heat to mechanical to electrical). 1 mark

Method I will generate a greater amount of electrical energy for a given mass of methanol. 1 mark

iii. In both methods, the complete oxidation of methanol will produce a set amount of the greenhouse gases carbon dioxide and water vapour. 1 mark

Therefore, neither method will produce a greater amount of greenhouse gases (even though method II is less efficient at producing electrical energy). 1 mark

(Method II may release more greenhouse gases if any of the steam used to turn the turbine is allowed to enter the atmosphere.)

Question 6 (4 marks)

Any two of:

1. There is some polarity in the ester functional group and so there will be dipole-dipole interactions between the molecules. These are a stronger type of force than dispersion forces.

5. As there are dipole-dipole forces between molecules of biodiesel, colder temperatures will intensify these forces as the molecules move more slowly and get closer together, and so the viscosity change will be greater than for petrodiesel.

6. Combustion of petrodiesel generates pollutants such as SO_2 and particulates in addition to CO_2 and H_2O. Emissions from the use of biodiesel contain fewer particulates and varying amounts of SO_2 depending on the oil source used.

7. Petrodiesel also contains approximately 25% aromatics (in addition to alkanes).

8. Both types of fuel require electrical energy for pumping, heat energy for vaporising and distilling and so on, and all of these energy requirements generate greenhouse gases. Farm machinery used in harvesting for biodiesel produces greenhouse gases.

4 marks
1 mark for each incorrect statement identified.
1 mark for each accurate explanation.