

# VCE CHEMISTRY 2009

## UNIT 4 TRIAL EXAMINATION SUGGESTED SOLUTIONS



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**Question 1    ANS A**

The equilibrium constant is very large. NO will react with O<sub>2</sub> to produce more NO<sub>2</sub>. More NO will be used up than O<sub>2</sub> since they react in a ratio of 2 : 1. Hence, NO will have the lowest concentration at equilibrium and NO<sub>2</sub> will have the highest concentration at equilibrium.

Let  $x$  be the number of mol of O<sub>2</sub> reacting.

The value of  $x$  could be calculated from the equilibrium expression :

$$K_c = \frac{(1+2x)^2}{(1-2x)^2(1-x)} = 6.6 \times 10^5$$

**Question 2    ANS C**

The forward reaction is exothermic. Therefore, a decrease in temperature will shift the equilibrium position to the right and increase the value of the equilibrium constant. Decreasing the volume of the container to 0.5 L will shift the position of equilibrium to the right but the value of the equilibrium constant will not change.

**Question 3    ANS B**

For the original equation  $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$ ,

$$\text{the equilibrium constant} = K_1 = \frac{[\text{NO}_2]^2}{[\text{NO}]^2[\text{O}_2]} = 6.6 \times 10^5$$

For the new equation  $\text{NO}_2(\text{g}) \rightleftharpoons \text{NO}(\text{g}) + \frac{1}{2}\text{O}_2(\text{g})$ ,

$$\text{the equilibrium constant} = K_2 = \frac{[\text{NO}][\text{O}_2]^{1/2}}{[\text{NO}_2]} = \frac{1}{\sqrt{K_1}} = \frac{1}{\sqrt{6.6 \times 10^5}}$$

**Question 4    ANS C**

From the Data Book, hydrogen peroxide as an oxidant has an  $E^0$  value of +1.77 V. As a reductant, hydrogen peroxide has an  $E^0$  value of +0.68 V. Hence, hydrogen peroxide will react with itself spontaneously. It is important to note that the  $E^0$  values give no information about the rate of reaction.

**Question 5    ANS D**

MnO<sub>2</sub> is a catalyst for the reaction and lowers the activation energy. Hence, more hydrogen peroxide molecules have sufficient energy to react.

**Question 6    ANS A**

When chemical bonds are broken, energy is absorbed. When chemical bonds form, energy is released. There is a net release of energy (exothermic reaction) because the energy absorbed in breaking all of the chemical bonds within the hydrogen and oxygen molecules is less than the energy released when the chemical bonds form to produce the water molecules.

**Question 7    ANS A**

Notice that the  $\Delta H_c$  values given in the Data Book are for one mol of each substance.

$$\text{Energy released (H}_2\text{)} = \frac{1.00}{2} \times 286 = 143 \text{ kJ} \text{ This is the largest.}$$

$$\text{Energy released (C)} = \frac{1.00}{12} \times 394 = 32.8 \text{ kJ}$$

$$\text{Energy released (CH}_4\text{)} = \frac{1.00}{16} \times 889 = 55.6 \text{ kJ}$$

$$\text{Energy released (C}_2\text{H}_6\text{)} = \frac{1.00}{30} \times 1557 = 51.9 \text{ kJ}$$

**Question 8    ANS A**

The forward reaction is endothermic. Therefore, the reverse reaction is exothermic. A decrease in temperature will favour the exothermic reaction. (Le Chatelier's Principle). The equilibrium position will shift to the left and the value of the equilibrium constant will decrease. There is an equal number of mole of gas on both sides of the equation. Hence, a change in volume does not change the position of equilibrium. An inert gas does not change the position of equilibrium. A catalyst does not change the position of equilibrium.

**Question 9    ANS B**

This is an exothermic reaction in which the heat content of the products is less than the heat content of the reactants. Energy is released. **Y** is the activation energy for the forward reaction. **Z** is the activation energy for the reverse reaction. **Y** the energy required to break the bonds in the reactants. **Z** the energy required to break the bonds in the products. **X** is the  $\Delta H$  value for the reaction.

$\Delta H = H(\text{products}) - H(\text{reactants})$ . This has a negative value.

**Question 10 ANS B**

To get the second equation from the first one, reverse the first equation and divide through by 2.

The new  $K_c$  value becomes  $\sqrt{\frac{1}{0.010}} = 10$ . The new unit becomes  $\frac{M^1}{M^{1/2}} = M^{1/2}$ .

The answer is  $10 M^{1/2}$ .

**Question 11 ANS C**

To get the second equation from the first one, reverse the first equation and divide through by 2.

The new  $\Delta H$  value becomes  $+\frac{58}{2}$ . The unit remain the same;  $\text{kJ mol}^{-1}$ .  $\Delta H$  for an equation is

**always written** as  $\text{kJ mol}^{-1}$ , where  $\text{mol}^{-1}$  means “per mole of equation as written”.

Answer is  $+29 \text{ kJ mol}^{-1}$ .

**Question 12 ANS D**

To this equilibrium system, extra product in the form of  $\text{H}_3\text{O}^+(\text{aq})$  is added. According to Le Chatelier's Principle, this will shift the equilibrium to the left. When equilibrium is re-established, there will be more  $\text{HNO}_2$ , more  $\text{H}_3\text{O}^+$  and less  $\text{NO}_2^-$ . However, the concentration fraction

$\frac{[\text{H}_3\text{O}^+][\text{NO}_2^-]}{[\text{HNO}_2]}$  will not have changed since the temperature remains constant.

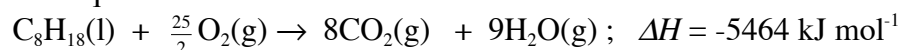
**Question 13 ANS D**

Sodium metal reacts with water and even more violently with acids. It must be kept out of contact with water and acids. An inert gas like nitrogen or an inert organic liquid like kerosene is ideal.

**Question 14 ANS B**

See the Data Book Section 13.

The equation for the molar heat of combustion of octane is



The energy released is 5464 kJ per mole of octane.

$$n(\text{octane}) = \frac{228}{114} = 2. \text{ Hence, the energy released} = 2 \times 5464 = 10\,928 \text{ kJ.}$$

**Question 15 ANS B**

$$\Delta H = \frac{k \times \Delta T}{1000 \times n}$$

$$\Delta T = \frac{\Delta H \times n}{k} = \frac{24.75 \times 1000 \times 0.100}{900} = 2.75 \text{ K}$$

Since  $\Delta H$  is positive, the temperature change is negative.

**Question 16 ANS D**

The number of mole of electrons required to deposit all of the copper

$$= 2 \times n(\text{Cu}^{2+})$$
$$= 2 \times \frac{1.876}{(63.6 + (2 \times 62.0))} = 2 \times \frac{1.876}{187.6} = 2 \times 0.01 = 0.02$$

The number of mole of electrons required to deposit all of the silver

$$= n(\text{Ag}^+)$$
$$= 1 \times \frac{0.8495}{(107.9 + 14.0 + 48.0)} = \frac{0.8495}{169.9} = 0.005$$

Hence, the quantity of electricity required =  $(0.02 + 0.005) \times 96\,500 = 2412.5 = 2413 \text{ C}$

**Question 17 ANS C**

In a galvanic cell, the positive electrode is the one to which the electrons flow, that is, the one at which the electrons are accepted. In this reaction, the oxidation number of silver changes from +1 to 0. Hence, Ag in  $\text{Ag}_2\text{O}(\text{s})$  has accepted an electron.  $\text{Ag}_2\text{O}(\text{s})$  is the positive electrode and has been reduced. It is the cathode because reduction **always** occurs at the cathode.

**Question 18 ANS A**

$$Q = I \times t = 0.05 \times 10^{-3} \times 100 \times 24 \times 3600 \text{ C}$$

$$n(\text{Ag}_2\text{O}) = \frac{1}{2} \times n(e^-) = \frac{0.05 \times 10^{-3} \times 100 \times 24 \times 3600}{2 \times 96500}$$

$$m(\text{Ag}_2\text{O}) = \frac{0.05 \times 10^{-3} \times 100 \times 24 \times 3600}{2 \times 96500} \times ((107.9 \times 2) + 16)$$

$$m(\text{Ag}_2\text{O}) = \frac{0.05 \times 10^{-3} \times 100 \times 24 \times 3600}{2 \times 96500} \times 231.8$$

$$m(\text{Ag}_2\text{O}) = \frac{0.05 \times 10^{-3} \times 100 \times 24 \times 3600}{2 \times 96500} \times 231.8 = 0.52 \text{ g}$$

**Question 19 ANS A**

Zn reduces  $\text{Ag}_2\text{O}$  to Ag. Hence, the  $E^0$  of the  $\text{Zn}(\text{OH})_2(\text{s})/\text{Zn}(\text{s})$  electrode must be less than that of the  $\text{Ag}_2\text{O}(\text{s})/\text{Ag}(\text{s})$  electrode.

Hence,  $E^0(\text{Zn}(\text{OH})_2(\text{s})/\text{Zn}(\text{s})) = -1.50 + 0.34 = -1.16 \text{ V}$

**Question 20 ANS D**

From (1)  $E^0(\text{Y}) > E^0(\text{X})$ ;

From (2)  $E^0(\text{Z}) > E^0(\text{X})$ ;

From (3)  $E^0(\text{Y}) > E^0(\text{Z})$

Hence,  $E^0(\text{Y}) > E^0(\text{Z}) > E^0(\text{X})$

**End of Section A  
Suggested Answers**

**Distribution: A 6 ; B 5 ; C 4 ; D 5**

Question 1

| Stage                                                 | Equation                                                                                                                                  | $\Delta H$ value<br>(+ or -)                                                                            |
|-------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| Energy produced by the sun                            | $4\text{}^1_1\text{H} \rightarrow \text{}^4_2\text{He} + 2\text{e}^+$<br>protons $\alpha$ -particle    positrons                          | <ul style="list-style-type: none"> <li>Negative</li> <li>Exothermic</li> <li>Energy released</li> </ul> |
| Energy stored in plants                               | $6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g})$ | <ul style="list-style-type: none"> <li>Positive</li> <li>Endothermic</li> <li>Energy stored</li> </ul>  |
| Combustion of the coal in the power station furnace   | $\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$                                                             | <ul style="list-style-type: none"> <li>Negative</li> <li>Exothermic</li> <li>Energy released</li> </ul> |
| Oxidation of sulfur impurities in the coal            | $\text{S}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{SO}_2(\text{g})$                                                             | <ul style="list-style-type: none"> <li>Negative</li> <li>Exothermic</li> <li>Energy released</li> </ul> |
| Boiling water to provide steam to drive the generator | $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g})$                                                                   | <ul style="list-style-type: none"> <li>Positive</li> <li>Endothermic</li> <li>Energy stored</li> </ul>  |

Question 2

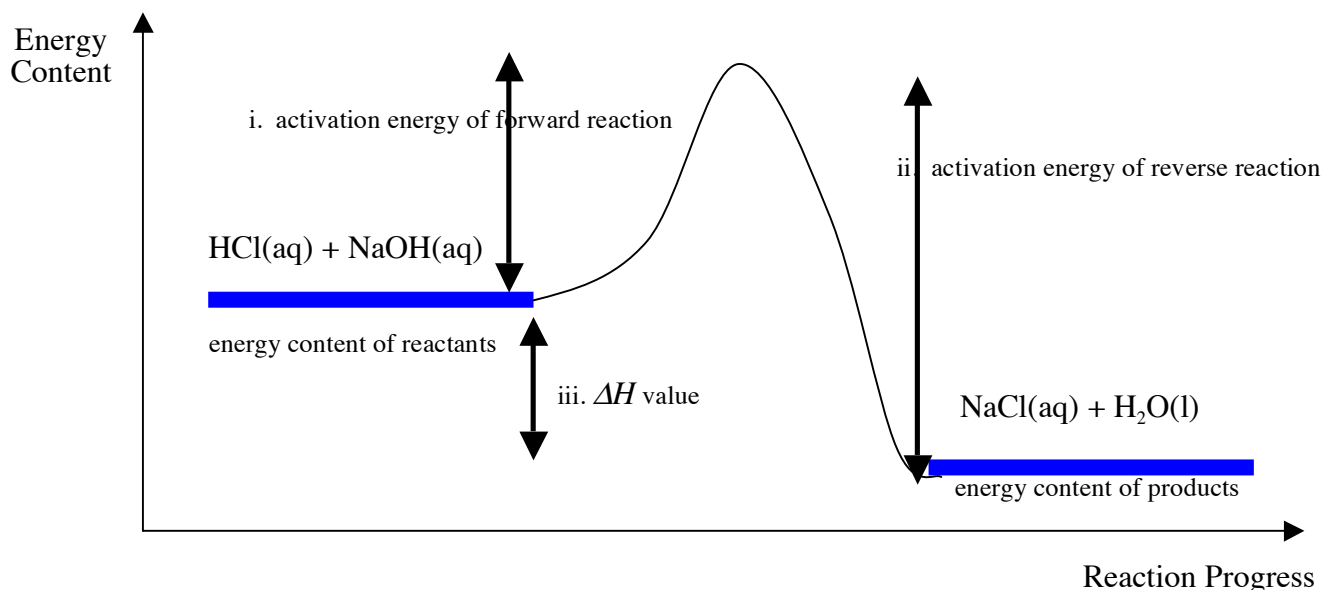
- a. i.  $\text{HCl}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- ii.  $\text{H}_3\text{O}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l})$  or  $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$
- b.  $n(\text{HCl}) \text{ reacting} = n(\text{NaOH}) \text{ reacting} = 0.5 \times 0.1 = 0.05 \text{ mol.}$

Energy released =  $140 \times 20.0 \text{ J.}$

$$\text{Hence, } \Delta H = -\frac{140 \times 20.0}{0.05 \times 1000} = -56 \text{ kJ mol}^{-1}$$

Question 2 (continued)

- c. The energy profile is shown below.



- d. i. The initial temperature of the calorimeter and its contents is 298 K. At this temperature, the value of  $K_w$  is  $1.0 \times 10^{-14}$ . After the reaction, the temperature rises to 318 K. The forward reaction is exothermic. Therefore, according to Le Chatelier's Principle, the reverse reaction is favoured and the  $[H^+]$  and  $[OH^-]$  both increase. Hence, the pH decreases. The pH is less than 7.
- ii. The solution is neutral because  $[H^+] = [OH^-]$ . This is the definition of neutrality. The concentrations have increased by the same amount.

Question 3

- a.  $\text{C}_2\text{H}_5\text{OH}(\text{aq}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})$
- b.  $\text{Mass}(\text{ethanol}) = \frac{2.9}{100} \times 500$   
 $n(\text{ethanol}) = \frac{2.9}{100} \times \frac{500}{46}$   
 $\text{Energy produced} = \frac{2.9}{100} \times \frac{500}{46} \times 1364(\text{Data Book}) = 430 \text{ kJ}$

Question 4

- a.  $\text{CH}_3\text{CHOHCOOH}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{CH}_3\text{CHOHCOO}^-(\text{aq})$   
or  $\text{HC}_3\text{H}_5\text{O}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{C}_3\text{H}_5\text{O}_3^-(\text{aq})$
- b. Use the Data Book for the  $K_a$  value of lactic acid. Assuming that the concentrations of  $\text{H}_3\text{O}^+(\text{aq})$  and  $\text{C}_3\text{H}_5\text{O}_3^-(\text{aq})$  are equal and that the concentration of  $\text{HC}_3\text{H}_5\text{O}_3(\text{aq})$  is very close to 0.001 M,  
$$K_a(\text{HC}_3\text{H}_5\text{O}_3) = \frac{[\text{H}_3\text{O}^+]_e [\text{C}_3\text{H}_5\text{O}_3^-]_e}{[\text{HC}_3\text{H}_5\text{O}_3]_e} = \frac{[\text{H}_3\text{O}^+]^2}{[\text{HC}_3\text{H}_5\text{O}_3]} = 1.4 \times 10^{-4} \text{ (Data Book)}$$
$$\Rightarrow [\text{H}_3\text{O}^+]^2 = 0.001 \times 1.4 \times 10^{-4} = 1.4 \times 10^{-7}$$
$$\Rightarrow [\text{H}_3\text{O}^+] = 3.74 \times 10^{-4} \text{ M}$$
$$\Rightarrow \text{pH} = 3.43$$
- c. When sodium lactate ( $\text{C}_3\text{H}_5\text{O}_3\text{Na}$ ) is added to the equilibrium,  $\text{C}_3\text{H}_5\text{O}_3^-(\text{aq})$  ions are added. In accordance with Le Chatelier's Principle, this shifts the equilibrium position to the left. The hydronium ion ( $\text{H}_3\text{O}^+$ ) concentration decreases and, therefore, the pH increases.

Question 5

- a.  $K_c = \frac{[\text{CH}_3\text{OH}]}{[\text{CO}] \cdot [\text{H}_2]^2} = \frac{4.00}{0.10 \times (0.20)^2} = \frac{4.00}{0.004} = 1000 \text{ M}^{-2}$
- b.  $[\text{CH}_3\text{OH}] = 1000 \times [\text{CO}] \times [\text{H}_2]^2$   
 $K_c$  does not change since the temperature remains the same.  
$$[\text{CH}_3\text{OH}] = 1000 \times 0.2 \times 0.04$$
$$= 8.0 \text{ M}$$
- c. The mixture of Cu, ZnO, and  $\text{Al}_2\text{O}_3$  acts as a catalyst. It increases the rate at which equilibrium is reached by lowering the activation energy of the reaction. A catalyst provides an alternative pathway for the reaction.

Question 5 (continued)

- d. 7 MPa is a very high pressure. More methanol is produced. Increasing the pressure in the reaction vessel shifts the equilibrium to the right since the reaction involves a **decrease** in the number of mole of gas (3 to 1).
- e. 250°C is a **compromise temperature** because a low temperature favours the production of methanol since the reaction for the production of methanol is exothermic. However, care would need to be taken that too low a temperature did not slow the rate of reaction by too much. A catalyst enables a much lower temperature to be used than would normally be the case. 250°C is a compromise between yield of methanol and the rate at which equilibrium is reached.

Question 6

a.

| Chemical      | Equilibrium Reaction                                                                                                                                                                                                   | Exothermic or endothermic |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| Ammonia       | $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$                                                                                                                               | Exothermic                |
| Ethene        | $\text{C}_2\text{H}_6(\text{g}) \rightleftharpoons \text{C}_2\text{H}_4(\text{g}) + \text{H}_2(\text{g})$ (many possible answers)                                                                                      | Endothermic               |
| Nitric acid   | $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$<br>or $4\text{NH}_3(\text{g}) + 5\text{O}_2(\text{g}) \rightleftharpoons 4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{g})$ | Both exothermic           |
| Sulfuric acid | $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$                                                                                                                              | Exothermic                |

b.

| Ammonia Reactants |                  | Ammonia Product |                  |
|-------------------|------------------|-----------------|------------------|
| Element           | Oxidation number | Element         | Oxidation number |
| N                 | 0                | N               | -3               |
| H                 | 0                | H               | +1               |

| Ethene Reactant |                  | Ethene Products |                  |
|-----------------|------------------|-----------------|------------------|
| Element         | Oxidation number | Element         | Oxidation number |
| C               | -3               | C               | -2               |
| H               | +1               | H               | +1               |
|                 |                  | H               | 0                |

Question 6

b. (continued)

| Nitric Acid Reactants |                  | Nitric Acid Product |                  |
|-----------------------|------------------|---------------------|------------------|
| Element               | Oxidation number | Element             | Oxidation number |
| N                     | +2               | N                   | +4               |
| O                     | -2               | O                   | -2               |
| O                     | 0                |                     |                  |

| Sulfuric Acid Reactants |                  | Sulfuric Acid Product |                  |
|-------------------------|------------------|-----------------------|------------------|
| Element                 | Oxidation number | Element               | Oxidation number |
| S                       | +4               | S                     | +6               |
| O                       | -2               | O                     | -2               |
| O                       | 0                |                       |                  |

- c. Many possible correct answers to these three questions
- i.  $\text{NH}_3$  (fertiliser),  $\text{C}_2\text{H}_4$  (polymer manufacture),  
 $\text{HNO}_3$  (explosive manufacture),  $\text{H}_2\text{SO}_4$  (dehydrating agent)
- ii. ammonia forms  $(\text{NH}_4)_2\text{SO}_4$ , ethene forms  $(\text{C}_2\text{H}_4)_n$ ,  
nitric acid form  $\text{NH}_4\text{NO}_3$ , sulfuric acid forms  $\text{Ca}(\text{H}_2\text{PO}_4)_2 + 2\text{CaSO}_4$
- iii.  $\text{NH}_3$  (carbon dioxide in the production of hydrogen),  $\text{C}_2\text{H}_4$  (all hydrocarbons),  
 $\text{HNO}_3$  (nitrogen dioxide producing photochemical smog),  $\text{H}_2\text{SO}_4$  (sulfur dioxide is a health hazard)

### Question 7

- a. At the cathode (-), an orange coating will form on the carbon electrode as copper metal is deposited in the reduction reaction:  $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Cu}(\text{s})$

At the anode (+) bubbles of a gas are formed. This is a pale yellow-green gas that has a distinctive strong smell. It is chlorine gas formed in the oxidation reaction:

$2\text{Cl}^{-}(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^{-}$ . Note that the concentration of the chloride ion in the solution is 4.0 M (not the standard 1.0 M) and so the chloride ion will be oxidised in preference to water.

- b. At the cathode (-), copper metal will be deposited until the concentration of copper ions in the solution becomes very low. At some point hydrogen gas will be produced in the reduction reaction:  $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^{-} \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^{-}(\text{aq})$ . An appropriate indicator will show the presence of hydroxide ions around the anode. Note that magnesium metal will **not** be produced at the cathode because water is present.

At the anode (+), chlorine gas will be formed until the concentration of the chloride ion in the solution decreases. At some point another gas will be produced. This gas will relight a glowing splint. It is oxygen gas formed in the oxidation reaction:

$2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 4\text{H}^{+}(\text{aq}) + 4\text{e}^{-}$ . An appropriate indicator will show the presence of hydrogen ions around the anode.

### Question 8

- a. A galvanic cell produces its own polarity with spontaneous chemical reactions. Hence, in an oxidation reaction (anode) in a galvanic cell, the electrode is negative. For example,  $\text{Zn}(\text{s}) \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{e}^{-}$ . On the other hand, an electrolytic cell has polarity forced upon it by an external power source. The negative terminal of the power source supplies electrons to the electrode. A non-spontaneous reaction occurs at the electrode. For example, the reduction reaction (cathode) in the electrolysis of water is  $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^{-} \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^{-}(\text{aq})$

- b. The balanced equation is:  $\text{Al}^{3+}(\text{l}) + 3\text{e}^{-} \rightarrow \text{Al}(\text{l})$ .

Therefore,  $n(\text{e}^{-}) = 3 \times n(\text{Al}) = 3 \times \frac{1500}{27.0}$

Now,  $Q = I \times t = n(\text{e}^{-}) \times F$ .

Hence,  $I = 3 \times \frac{1500}{27.0} \times \frac{96500}{3600} = 4467.6 = 4468 \text{ A}$

- c. Let  $Y$  = the number of electrons used in the reduction half-equation. In  $\text{Fe}^{3+}(\text{aq})$ , the oxidation state of Fe is +3. The number of mole of  $\text{Fe}^{3+}(\text{aq}) = \frac{1}{55.9}$

$$n(\text{e}^{-}) = Y \times \frac{1}{55.9} \text{ and } n(\text{e}^{-}) = \frac{Q}{F} = \frac{5179}{96500}$$

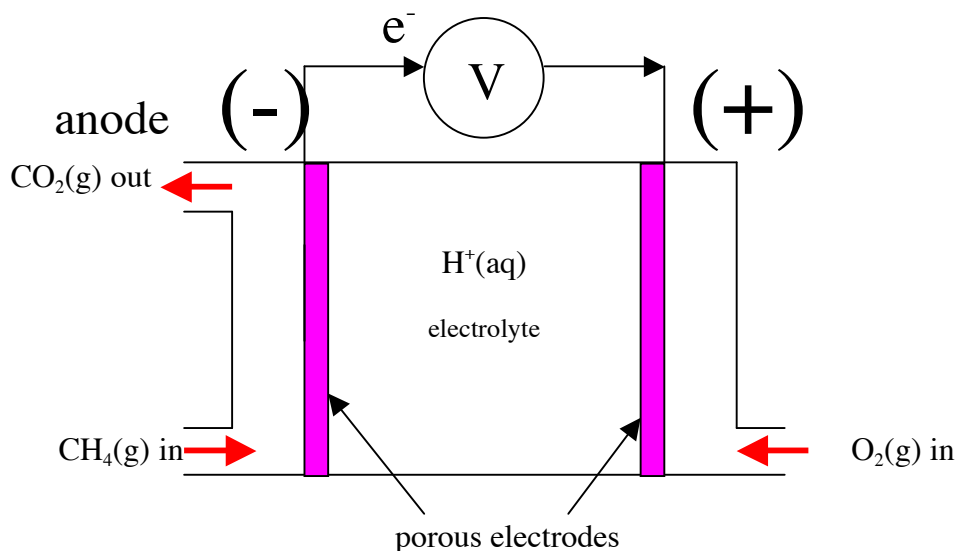
$$\text{Hence, } Y = \frac{5179 \times 55.9}{96500} = 3$$

Therefore, the final oxidation number of iron = 3 - 3 = 0

The reaction occurring is  $\text{Fe}^{3+}(\text{aq}) + 3\text{e}^{-} \rightarrow \text{Fe}(\text{s})$

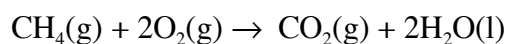
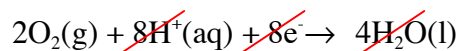
Question 9

- a. i. The anode is the electrode at which oxidation (loss of electrons) occurs. It is negative. This is the electrode on the left hand side as shown below.
- ii. The electrons flow from left to right through the external circuit (the voltmeter V) as shown below.



- b. Anode half-reaction:  $\text{CH}_4(\text{g}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow \text{CO}_2(\text{g}) + 8\text{H}^+(\text{aq}) + 8\text{e}^-$
- c. Cathode half-reaction:  $\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$

The overall cell reaction is obtained by adding the anode half equation to twice the cathode half equation as shown below.



Question 9 (continued)

d.



From the half equation, assuming 100% efficiency,  $n(\text{CH}_4)$

$$= \frac{1}{8} \times n(\text{e}^-)$$

$$= \frac{1}{8} \times \frac{Q}{F}$$

$$= \frac{1}{8} \times \frac{I \times t}{F}$$

$$= \frac{1}{8} \times \frac{10.0 \times 24 \times 3600}{96500}$$

$$= 1.1192$$

Hence,  $V(\text{CH}_4)$  under SLC =  $1.1192 \times 24.5 \text{ dm}^3 = 27.42 \text{ dm}^3$ .

Since the process is only 75% efficient, the volume of  $\text{CH}_4$  required will be **greater**.

$$V(\text{CH}_4) \text{ required} = \frac{27.42}{0.75} = 36.6 \text{ dm}^3$$

END OF SUGGESTED SOLUTIONS

2009 VCE CHEMISTRY TRIAL WRITTEN EXAMINATION 2

|                                                                           |                                                                                                                                                                                                        |
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