

**SECTION A (Total 20 marks)**

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

**Comments for Section A answers****Question 1**

$\Delta T$  should be higher, so CF should be lower and actual  $\Delta H$  would be lower. (Answer A)

**Question 2**

According to the Electrochemical Series,  $2\text{H}_2\text{O} + 2\text{e} \rightarrow \text{H}_2 + 2\text{OH}^-$   
 $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}$  (Answer D)

**Question 3**

$[\text{Ba}(\text{OH})_2] = 0.050 \text{ M}$   $[\text{OH}^-] = 0.10 \text{ M}$   $\text{pOH} = 1.0$   $\text{pH} = 13$  (Answer D)

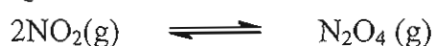
**Question 4**

Need  $Q = I \times t$ , need  $n(\text{e}) = Q/F$ , need charge per electron, need  $n(\text{metal})$ .  
 You need to know the  $m(\text{Cu})$  deposited not the concentration of the  $\text{Cu}^{2+}$  ions. (Answer B)

**Question 5**

$\text{Mg}^{2+} + 2\text{e} \rightarrow \text{Mg}$   $\text{Al}^{3+} + 3\text{e} \rightarrow \text{Al}$   
 For a fixed number of mole of electrons eg.  $n(\text{e}) = 3$ ,  
 $n(\text{Mg}) = 1.5$   $n(\text{Al}) = 1.0$   
 $m(\text{Mg}) = n \times M = 1.5 \times 24.3 = 36.5 \text{ g}$   $m(\text{Al}) = n \times M = 1.0 \times 27.0 = 27.0 \text{ g}$

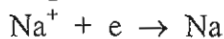
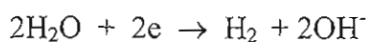
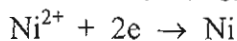
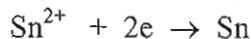
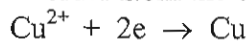
$m(\text{Mg}) / m(\text{Al}) = 36.5 / 27.0 = 1.35$  (Answer C)

**Question 6**

As  $V \uparrow$ ,  $P \downarrow$  so according to LCP, overall P must increase to restore equilibrium. To do this, there must be a net reaction to produce more particles ie.  $\text{NO}_2$  and so its concentration increases at the expense of  $\text{N}_2\text{O}_4$ . (Answer B)

**Question 7**

In order from the electrochemical series



$\text{Cu}^{2+}$ ,  $\text{Sn}^{2+}$ ,  $\text{Ni}^{2+}$  are all stronger oxidants than water and will be preferentially reduced.  
 $\text{H}_2\text{O}$  is a stronger oxidant than  $\text{Na}^+$  and will be preferentially reduced. (Answer C)

**Question 8**

Zinc increases its oxidation number from 0 to +2 and is therefore oxidised. The zinc releases electrons and so is the negative electrode or anode in a galvanic cell. (Answer **D**)

**Question 9**

$$Q = I \times t \quad Q = 0.100 \times 10^{-3} \times 7257600 \text{ C} = 725.8 \text{ C}$$

$$n(e) = Q / F = 725.8 / 96500 = 7.52 \times 10^{-3} \text{ mol}$$

$$n(\text{Ag}_2\text{O}) = \frac{1}{2} n(e)$$

$$m(\text{Ag}_2\text{O}) = \frac{1}{2} \times 7.52 \times 10^{-3} \times 288 = 1.08 \times 10^{-3} \text{ g} \quad (\text{Answer } \mathbf{B})$$

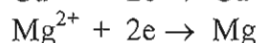
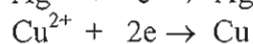
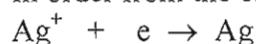
**Question 10**

$$E_{\text{cell}} = E^{\circ}(+) - E^{\circ}(-) \quad 1.50 = 0.34 - E^{\circ}(-)$$

$$\text{Therefore } E^{\circ}(-) = 0.34 - 1.50 = -1.16 \quad (\text{Answer } \mathbf{A})$$

**Question 11**

In order from the electrochemical series



The oxidant must be higher placed than the reductant for reaction to occur. There is no suitable oxidant present to oxidise Ag. No reaction. (Answer **D**)

**Question 12**

Given ammonia is a weak base, only a relatively small proportion of ammonia molecules are ionised at any point in time. (Answer **A**)

**Question 13**

According to LCP, if  $T \uparrow$ , the system will respond by trying to reduce temperature and move in the endothermic direction i.e. a net backward reaction.

According to LCP, if  $P \uparrow$ , the system will respond by trying to reduce pressure and move in the direction which produces less molecules i.e. a net forward reaction. Two conflicting responses are occurring and it is impossible to predict the net outcome. (Answer **B**)

**Question 14**

$$\text{At pH} = 1, [\text{H}^+] = 10^{-1}$$

$$K = \frac{[\text{H}^+][\text{In}^-]}{[\text{HIn}]}$$

$$K / [\text{H}^+] = \frac{[\text{In}^-]}{[\text{HIn}]} = 10^{-8} / 10^{-1} = 10^{-7} \text{ which is very small so HIn predominates and the colour is red. (Answer } \mathbf{A})$$

**Question 15**

The  $[\text{In}^-] / [\text{HIn}] = 1$ , means that there is the same concentration of red and blue, therefore the colour will appear purple. (Answer **D**)

**Question 16**

$$K_a = \frac{[\text{H}^+][\text{B}(\text{OH})_4^-]}{[\text{B}(\text{OH})_3]}$$

$$[\text{H}^+]^2 = K_a [\text{B}(\text{OH})_3] = 5.8 \times 10^{-10} \times 0.50 = 2.9 \times 10^{-10}$$

$$[\text{H}^+] = \sqrt{2.9 \times 10^{-10}} = 1.7 \times 10^{-5}$$

$$\text{pH} = 4.8 \quad (\text{Answer } \mathbf{B})$$

**Question 17**

$$\Delta H = E_{\text{in}} - E_{\text{out}} = E_{\text{bond breaking}} - E_{\text{bond making}}$$

$$-3114 = 2 \times 275 - E_{\text{bond making}}$$

$$E_{\text{bond making}} = 3664 \text{ kJ (Answer D)}$$

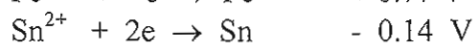
**Question 18**

The original solution has  $[\text{OH}^-] = 1.0 \times 10^{-4}$

The solution is being diluted by 100.

The concentration of  $\text{OH}^-$  ions is now  $1.0 \times 10^{-6}$

$\text{pOH} = 6$ ,  $\text{pH} = 8$  (Answer A)

**Question 19**

Electrons flow from the strongest reductant (Sn) to the strongest oxidant ( $\text{Fe}^{3+}$ ) via the external circuit and the platinum. The Sn is oxidised and so is the anode and is assigned the negative polarity. (Answer D)

**Question 20**

As  $\text{Fe}^{3+}$  ions are being converted into  $\text{Fe}^{2+}$  ions, the positive charge in the cathode half cell would decrease unless compensated for by the movement of  $\text{K}^+$  ions to this half cell. (Answer B)

## SECTION B

## Question 1 (8 marks)

- a. A weak acid only undergoes a small amount of ionisation to produce  $H^+$  ions. (1 mark)
- b.  $CH_3COOH$  is a weak acid and therefore the  $[CH_3COO^-]$  cannot be directly calculated from the concentration of  $CH_3COOH$ . (1 mark)

$$K_a(CH_3COOH) = 1.7 \times 10^{-5} \text{ (from the data booklet)}$$

$$K_a = [H^+][CH_3COO^-] / [CH_3COOH] \quad (1 \text{ mark})$$

$$[CH_3COO^-] = [H^+] \quad (1 \text{ mark})$$

$$[CH_3COO^-]^2 = K_a [CH_3COOH] = 1.7 \times 10^{-5} \times 0.0500 = 8.5 \times 10^{-7}$$

$$[CH_3COO^-] = \sqrt{8.5 \times 10^{-7}} = 9.2 \times 10^{-4} \quad (1 \text{ mark})$$

A consequential mark can be awarded if a student incorrectly assumes a strong acid and correctly calculates a pH based on this.

- c.  $CH_3COO^-(aq) + H_2O(l) \rightleftharpoons OH^-(aq) + CH_3COOH(aq)$  (1 + 1 marks)  
Equilibrium arrow must be included together with states.

- d.  $K = [OH^-][CH_3COOH] / [CH_3COO^-]$  (1 mark)

## Question 2 (13 marks)

- a.  $K = [CO][H_2]^3 / [CH_4][H_2O]$  (1 mark)
- b. i.  $K \uparrow$  (1 mark)  
explanation: LCP requires T to decrease; forward reaction is endothermic. K increases (1 mark)
- ii. no change in K (1 mark)  
explanation: although the CF changes the system returns to the original CF value at the same temperature. (1 mark)
- iii. no change in K (1 mark)  
explanation: equilibrium is established faster but same K value. (1 mark)
- c. i.  $n(H_2) \downarrow$  (1 mark)  
explanation: LCP requires P to decrease; need less molecules; net backward reaction to produce less molecules.  $n(H_2)$  will decrease. (1 mark)
- ii.  $n(H_2) \uparrow$  (1 mark)  
explanation: LCP will require  $T \downarrow$ ; a net forward reaction occurs to produce more hydrogen as the forward reaction is endothermic. (1 mark)
- iii. no change to  $n(H_2)$  (1 mark)  
explanation: equilibrium is established faster but same K value and same amount of  $H_2$  (1 mark)

**Question 3 (4 marks)**

$$\Delta T = 25.40 - 21.10 \text{ }^\circ\text{C} = 4.30 \text{ }^\circ\text{C}$$

$$n(\text{Ag}) = c \times V = 0.100 \times 50.0 \times 10^{-3} = 5.00 \times 10^{-3} \text{ mol (1 mark)}$$

$$\text{energy released} = mc\Delta T = 50.0 \times 4.18 \times 4.3 = 899 \text{ J (1 mark)}$$

$$899 \text{ J} / (5.00 \times 10^{-3}) \text{ mol} = x \text{ J} / 2.00 \text{ mol (1 mark)}$$

$$x = 3.60 \times 10^5 \text{ J} = 360 \text{ kJ}$$

$$\Delta H = -360 \text{ kJ mol}^{-1} \text{ (1 mark)}$$

**Question 4 (5 marks)**

- a.  $\Delta H_2$  represents the formation of methane (1 mark)
- b.  $\Delta H_3$  = atomisation of C + atomisation of 2 moles of  $\text{H}_2$  (1 mark)  
 $= 218 + 717 \times 2 = 1652 \text{ kJ (1 mark)}$
- c.  $\Delta H_1$  = reverse of  $\Delta H_2 + \Delta H_3$  (1 mark)  
 $= 74 + 1652 = 1726 \text{ kJ (1 mark)}$

**Question 5 (6 marks)**

- a. i. Acidic (1 mark)  
ii. The self ionisation of water is endothermic. At lower temp, K is smaller therefore neutral pH must be above 7 (1 mark). Therefore the blood must be acidic.
- b. i.  $M(\text{NaOH}) = 40.0 \text{ g mol}^{-1}$   $n(\text{NaOH}) = m / M = 150 / 40.0 = 3.75 \text{ mol (1 mark)}$   
 $[\text{NaOH}] = n / V = 3.75 / 1.00 = 3.75 \text{ M (1 mark)}$   
 $\text{pOH} = -\log_{10}[\text{OH}^-] = -\log_{10} 3.75 = -0.58$   
ii.  $\text{pH} = 14 + 0.58 = 14.58 \text{ (1 mark)}$

**Question 6 (6 marks)**

- a. anode (-) was zinc, cathode (+) was copper (1 mark)  
Electrons flowed from Zn to Cu (1 mark)
- b. i.  $\text{Zn(s)} \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{e}^-$  (1 mark)  
ii.  $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2$  (1 mark)
- c. To provide ions to complete the internal circuit (1 mark)  
It is acidic and provides  $\text{H}^+$  ions (1 mark)

**Question 7 (9 marks)**

- a.  $\text{Ag}^+(\text{aq}) + \text{e} \rightarrow \text{Ag}$  (1 mark)
- b.  $2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}$  (1 mark)
- c.  $n(\text{Ag}) = 0.00100 \text{ mol}$  (1 mark)  
 $n(\text{e}) = 0.00100 \text{ mol}$  (1 mark)  
 $Q = n(\text{e}) \times F = 0.00100 \times 96\,500 = 96.5 \text{ C}$  (1 mark)  
 $T = Q / I = 96.5 / 0.5$  (1 mark) = 193 s (1 mark)
- d. copper would be deposited (1 mark)
- e. No. Water is a stronger oxidant and would be preferentially reduced. (1 mark)

**Question 8 (9 marks)**

Sample Answer for Production of Concentrated Sulfuric Acid

- a.  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$   $\Delta\text{H}$  is negative (1 mark)
- b. approx  $450^\circ\text{C}$  (1 mark)  
a catalyst. (1 mark)  
excess oxygen is also used. (1 mark)
- c. e.g. any  $\text{SO}_2$  not converted initially can be recycled back to the catalytic converter to improve the percentage conversion. (1 mark)
- d. e.g. Strong acid (1 mark)  $\text{H}_2\text{SO}_4(\text{l}) + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{HSO}_4^-(\text{aq})$  (1 mark)  
Production of fertiliser (1 mark)  $\text{H}_2\text{SO}_4(\text{l}) + 2\text{NH}_3(\text{g}) \rightarrow (\text{NH}_4)_2\text{SO}_4(\text{aq})$  (1 mark)  
Many other possibilities.

**END OF SUGGESTED SOLUTIONS**

