

SECTION A (Total 20 marks)

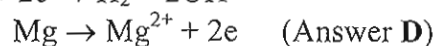
1.	A	2.	D	3.	D	4.	B	5.	C
6.	B	7.	C	8.	D	9.	B	10.	A
11.	D	12.	A	13.	B	14.	A	15.	D
16.	B	17.	D	18.	A	19.	D	20.	B

Comments for Section A answers**Question 1**

ΔT should be higher, so CF should be lower and actual ΔH would be lower. (Answer A)

Question 2

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

**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 Cu^{2+} ions. (Answer B)

Question 5

For a fixed number of mole of electrons eg. $n(\text{e}) = 3$,

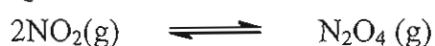
$$n(\text{Mg}) = 1.5$$

$$n(\text{Al}) = 1.0$$

$$m(\text{Mg}) = n \times M = 1.5 \times 24.3 = 36.5 \text{ g}$$

$$m(\text{Al}) = n \times M = 1.0 \times 27.0 = 27.0 \text{ g}$$

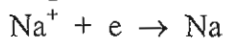
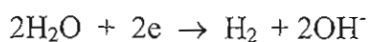
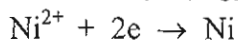
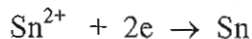
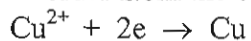
$$m(\text{Mg}) / m(\text{Al}) = 36.5 / 27.0 = 1.35 \quad (\text{Answer C})$$

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. NO_2 and so its concentration increases at the expense of N_2O_4 . (Answer B)

Question 7

In order from the electrochemical series



Cu^{2+} , Sn^{2+} , Ni^{2+} are all stronger oxidants than water and will be preferentially reduced.

H_2O is a stronger oxidant than 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

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

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

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

$$m(\text{Ag}_2\text{O}) = \frac{1}{2} \times 7.52 \times 10^{-3} \times 288 = 3.76 \times 10^{-3} \text{ g} \quad (\text{Answer } \mathbf{B})$$

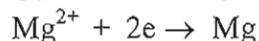
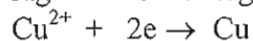
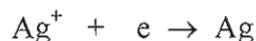
Question 10

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

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

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

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

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

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

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

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

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

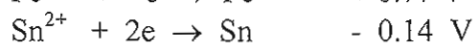
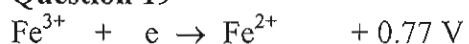
Question 18

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

The solution is being diluted by 100.

The concentration of OH^- ions is now 1.0×10^{-6}

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

Question 19

Electrons flow from the strongest reductant (Sn) to the strongest oxidant (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 Fe^{3+} ions are being converted into Fe^{2+} ions, the positive charge in the cathode half cell would decrease unless compensated for by the movement of 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 $[\text{CH}_3\text{COO}^-]$ cannot be directly calculated from the concentration of CH_3COOH . (1 mark)

$$K_a(\text{CH}_3\text{COOH}) = 1.7 \times 10^{-5} \text{ (from the data booklet)}$$

$$K_a = [\text{H}^+][\text{CH}_3\text{COO}^-] / [\text{CH}_3\text{COOH}] \quad (1 \text{ mark})$$

$$[\text{CH}_3\text{COO}^-] = [\text{H}^+] \quad (1 \text{ mark})$$

$$[\text{CH}_3\text{COO}^-]^2 = K_a [\text{CH}_3\text{COOH}] = 1.7 \times 10^{-5} \times 0.0500 = 8.5 \times 10^{-7}$$

$$[\text{CH}_3\text{COO}^-] = \sqrt{(8.5 \times 10^{-7})} = 9.2 \times 10^{-4} \quad (1 \text{ mark})$$

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

- c. $\text{CH}_3\text{COO}^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{OH}^-(\text{aq}) + \text{CH}_3\text{COOH}(\text{aq}) \quad (1 + 1 \text{ marks})$
Equilibrium arrow must be included together with states.

- d. $K = [\text{OH}^-][\text{CH}_3\text{COOH}] / [\text{CH}_3\text{COO}^-] \quad (1 \text{ mark})$

Question 2 (13 marks)

- a. $K = [\text{CO}][\text{H}_2]^3 / [\text{CH}_4][\text{H}_2\text{O}] \quad (1 \text{ mark})$
- 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. $n(\text{H}_2) \downarrow$ (1 mark)
explanation: LCP requires P to decrease; need less molecules; net backward reaction to produce less molecules. $n(\text{H}_2)$ will decrease. (1 mark)
- ii. $n(\text{H}_2) \uparrow$ (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 $n(\text{H}_2)$ (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. ΔH_2 represents the formation of methane (1 mark)
- b. ΔH_3 = atomisation of C + atomisation of 2 moles of H_2 (1 mark)
 $= 218 + 717 \times 2 = 1652 \text{ kJ (1 mark)}$
- c. ΔH_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 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. $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$ ΔH is negative (1 mark)
- b. approx 450°C (1 mark)
a catalyst. (1 mark)
excess oxygen is also used. (1 mark)
- c. e.g. any 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

1

2

3