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, $2H_2O + 2e \rightarrow H_2 + 2OH^-$
$Mg \rightarrow Mg^{2+} + 2e$ (Answer **D**)

Question 3
$[Ba(OH)_2] = 0.050$ M $[OH^-] = 0.10$ M pOH = 1.0 pH = 13 (Answer **D**)

Question 4
Need Q = I x t, need n(e) = Q/F, need charge per electron, need n(metal).
You need to know the m(Cu) deposited not the concentration of the Cu^{2+} ions. (Answer **B**)

Question 5
$Mg^{2+} + 2e \rightarrow Mg$ $Al^{3+} + 3e \rightarrow Al$
For a fixed number of mole of electrons eg. n(e) = 3,
n(Mg) = 1.5 n(Al) = 1.0
m(Mg) = n x M = 1.5 x 24.3 = 36.5 g m(Al) = n x M = 1.0 x 27.0 = 27.0 g

m(Mg) / m(Al) = 36.5 / 27.0 = 1.35 (Answer **C**)

Question 6
$2NO_2(g) \rightleftharpoons N_2O_4(g)$
As V↑, P ↓ 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
$Cu^{2+} + 2e \rightarrow Cu$
$Sn^{2+} + 2e \rightarrow Sn$
$Ni^{2+} + 2e \rightarrow Ni$
$2H_2O + 2e \rightarrow H_2 + 2OH^-$
$Na^+ + e \rightarrow Na$

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
$Q = I \times t \quad Q = 0.100 \times 10^{-3} \times 7257600\ C = 725.8\ C$
$n(e) = Q / F = 725.8 / 96500 = 7.52 \times 10^{-3}$ mol
$n(Ag_2O) = \frac{1}{2}\ n(e)$
$m(Ag_2O) = \frac{1}{2} \times 7.52 \times 10^{-3} = 3.76 \times 10^{-3}$ (Answer **B**)

Question 10
$E_{cell} = E^\circ(+) - E^\circ(-) \qquad 1.50 = 0.34 - E^\circ(-)$

Therefore $E^\circ(-) = 0.34 - 1.50 = -1.16$ (Answer **A**)

Question 11
In order from the electrochemical series
$Ag^+ + e \rightarrow Ag$
$Cu^{2+} + 2e \rightarrow Cu$
$Mg^{2+} + 2e \rightarrow Mg$
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↑, 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↑, 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 pH = 1, $[H^+] = 10^{-1}$
$K = [H^+][In^-] / [HIn]$
$K / [H^+] = [In^-] / [HIn] = 10^{-8} / 10^{-1} = 10^{-7}$ which is very small so HIn predominates and the colour is red. (Answer **A**)

Question 15
The $[In^-] / [HIn] = 1$, means that there is the same concentration of red and blue, therefore the colour will appear purple. (Answer **D**)

Question 16
$K_a = [H^+][B(OH)_4^-] / [B(OH)_3]$

$[H^+]^2 = K_a [B(OH)_3] = 5.8 \times 10^{-10} \times 0.50 = 2.9 \times 10^{-10}$
$[H^+] = \sqrt{(2.9 \times 10^{-10})} = 1.7 \times 10^{-5}$
pH = 4.8 (Answer **B**)

Question 17

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

$-3114 = 2 \times 275 - E_{\text{bond making}}$ $E_{\text{bond making}} = 3664$ kJ (Answer **D**)

Question 18

The original solution has $[OH^-] = 1.0 \times 10^{-4}$
The solution is being diluted by 100.
The concentration of OH^- ions is now 1.0×10^{-6}
pOH = 6, pH = 8 (Answer **A**)

Question 19

$Fe^{3+} + e \rightarrow Fe^{2+}$ + 0.77 V
$Sn^{2+} + 2e \rightarrow Sn$ - 0.14 V

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 $[CH_3COO^-]$ cannot be directly calculated from the concentration of CH_3COOH. **(1 mark)**

K_a (CH_3COOH) = 1.7×10^{-5} (from the data booklet)

$K_a = [H^+][CH_3COO^-] / [CH_3COOH]$ **(1 mark)**

$[CH_3COO^-] = [H^+]$ **(1 mark)**

$[CH_3COO^-]^2 = K_a [CH_3COOH] = 1.7 \times 10^{-5} \times 0.0500 = 8.5 \times 10^{-7}$
$[CH_3COO^-] = \sqrt{(8.5 \times 10^{-7})} = 9.2 \times 10^{-4}$ **(1 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 ↑ **(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.** $n(H_2)$ ↓ **(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. $n(H_2)$ ↑ **(1 mark)**
explanation: LCP will require T↓; 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)

$\Delta T = 25.40 - 21.10\ ^{\circ}C = 4.30\ ^{\circ}C$
$n(Ag) = c \times V = 0.100 \times 50.0 \times 10^{-3} = 5.00 \times 10^{-3}$ mol **(1 mark)**
energy released = $mc\Delta T = 50.0 \times 4.18 \times 4.3 = 899$ J **(1 mark)**

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

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

$\Delta H = -360$ kJ mol^{-1} **(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 x 2 = 1652 kJ **(1 mark)**

c. ΔH_1 = reverse of $\Delta H_2 + \Delta H_3$ **(1 mark)**
= 74 + 1652 = 1726 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(NaOH) = 40.0 g mol^{-1} n(NaOH) = m / M = 150 / 40.0 = 3.75 mol **(1 mark)**

[NaOH] = n / V = 3.75 / 1.00 = 3.75 M **(1 mark)**

$pOH = -\log_{10}[OH^-] = -\log_{10} 3.75 = -0.58$

ii. pH = 14 + 0.58 = 14.58 **(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.** $Zn(s) \rightarrow Zn^{2+}(aq) + 2e$ **(1 mark)**
ii. $2H^+(aq) + 2e \rightarrow H_2$ **(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. $Ag^+(aq) + e \rightarrow Ag$ **(1 mark)**

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

c. n(Ag) = 0.00100 mol **(1 mark)**
n(e) = 0.00100 mol **(1 mark)**
Q = n(e) x F = 0.00100 x 96 500 = 96.5 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. $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ 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)** $H_2SO_4(l) + H_2O \rightarrow H_3O^+(aq) + HSO_4^-(aq)$ **(1 mark)**

Production of fertiliser **(1 mark)** $H_2SO_4(l) + 2NH_3(g) \rightarrow (NH_4)_2SO_4(aq)$ **(1 mark)**

Many other possibilities.

END OF SUGGESTED SOLUTIONS