$$\%\,composition = \frac{0.164}{0.25} \times 100 = 65.5\%$$

16.

(a) $2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H^+(aq) \rightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$

(b) $MnO_4^-(aq) + 8\,H^+(aq) + 5Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$

(c) $n(Fe^{2+})$ in titre $= 0.0081 \times 0.01267$
$= 1.102 \times 10^{-4}$ mol
From tables $n(MnO_4^-) = 5 \times (Fe^{2+})$ so:
$n(MnO_4^-)$ in aliquot $= 1/5 \times 1.102 \times 10^{-4}$ mol
$= 2.205 \times 10^{-5}$ mol in 20 mL
Total volume of MnO_4^- solution $= 100 + 50$
$= 150$ mL
$n(MnO_4^-)$ in 250 mL $= 2.205 \times 10^{-5} \times \frac{150}{20}$
$= 1.654 \times 10^{-4}$ mol $= n_2$.

$n_1 = 0.0052 \times 0.050 = 2.60 \times 10^{-4}$ mol.
$n(MnO_4^-)$ reacted $= n_1 - n_2$
$= 2.60 \times 10^{-4} - 1.654 \times 10^{-4} = 9.463 \times 10^{-5}$ mol.
From tables: $n(C_2O_4^{2-}) = 5/2 \times n(MnO_4^-)$
$= 9.463 \times 10^{-5} \times \frac{5}{2} = 2.366 \times 10^{-4}$ mol
$n(C_2O_4^{2-}) = n(Ca^{2+})$
$\therefore n(Ca^{2+}) = 2.366 \times 10^{-4}$ mol
So: $m(Ca) = 2.366 \times 10^{-4} \times 40.08$
$= 0.00948$ g (9.48 mg) in 100 mL of blood.

(d) $[Ca^{2+}] = \frac{2.366 \times 10^{-4}}{0.1} = 2.366 \times 10^{-3}$ mol L^{-1}

Set 4 Exercises and Problems

Multiple Choice Answers

1. e, 2. e, 3. a, 4. a, 5. d, 6. d, 7.e, 8. c, 9. b, 10. b, 11. e, 12. b, 13. e

Long Questions Answers

1.

(a) $F_2(g)$ (b) $K(s)$ (c) $F_2(g)$ (d) $K(s)$

(e) $Zn \rightarrow Zn^{2+} + 2e^-$ +0.76 V
$Fe^{2+} + 2e^- \rightarrow Fe$ -0.44 V
$Zn + Fe^{2+} \rightarrow Zn^{2+} + Fe$ +0.32 V

(f) i) $3 \times (O_2 + 2H_2O + 4e^- \rightarrow 4OH^-)$ +0.40 V
$1 \times (Cr \rightarrow Cr^{3+} + 3e^-)$ +0.74 V
$3O_2 + 6H_2O + 4Cr \rightarrow 12OH^- + 4Cr^{3+}$ +1.14 V

ii) $I_2 + 2e^- \rightarrow 2I^-$ +0.54 V
$2 \times (Au + 2CN^- \rightarrow Au(CN)_2^- + e^-)$ +0.60 V
$I_2 + 2Au + 4\,CN^- \rightarrow 2I^- + 2Au(CN)_2^-$ +1.14 V

(g) $2 \times (Fe \rightarrow Fe^{2+} + 2e^-)$ +0.44 V
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$ +0.40 V
$2Fe + O_2 + 2H_2O \rightarrow 2Fe^{2+} + 4OH^-$ +0.84 V

2.

(a) $Ca \rightarrow Ca^{2+} + 2e-$ +2.87 V
$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ -0.41 V
$Ca + 2H_2O \rightarrow Ca^{2+} + H_2 + 2OH^-$
+2.46 V Reaction will occur.

(b) $2 \times (MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O)$ +1.51 V
$5 \times (Sn^{2+} \rightarrow Sn^{4+} + 2e^-)$ -0.15 V
$2MnO_4^- + 16H^+ + 5Sn^{2+} \rightarrow 2Mn^{2+} + 8H_2O + 5Sn^{4+}$
$E^0 = +1.36$ V Reaction will occur.

(c) $Na^+ + e^- \rightarrow Na$ -2.71 V
$K \rightarrow K^+ + e^-$ +2.93 V
$Na^+ + K \rightarrow Na + K^+$
+0.22 V Reaction will occur.

3.

(a) $Ni \rightarrow Ni^{2+} + 2e^-$ +0.26 V
$2 \times (Ag^+ + e^- \rightarrow Ag)$ +0.80 V
$Ni + 2Ag^+ \rightarrow Ni^{2+} + 2Ag$ +1.06 V

(b) $2Cr^{3+} + 7H_2O \rightarrow Cr_2O_7^{2-} + 14H^+ + 6e^-$ -1.23 V
$3 \times (H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O)$ +1.78 V
$2Cr^{3+} + 7H_2O + 3H_2O_2 \rightarrow Cr_2O_7^{2-} + 8H^+ + 6H_2O$ +0.55 V

(c) $Zn \rightarrow Zn^{2+} + 2e^-$ +0.76 V
$Ni^{2+} + 2e^- \rightarrow Ni$ -0.26 V
$Zn + Ni^{2+} \rightarrow Zn^{2+} + Ni$ +0.50 V

4.

(a) Copper ions are receiving the negative charges which flow towards the positive electrode.

(b) Zinc gives away the negative charges so it must be charged negative.

(c) 1.10 V (0.76 + 0.34 = 1.10 V).

(d) Copper oxidises zinc.

(e) 1.10 V.

(f) The same as before (1.10 V).

5. The assigned E^0 value for each will increase by 2.93 V.

6.

(a) $2Au(s) + 8Br^-(aq) + 3IO^-(aq) + 3H_2O(l) \rightarrow 2AuBr_4^-(aq) + 3I^-(aq) + 6OH^-(aq)$
$E^0 = 0.858 + 0.49 = 1.35$ V

(b) $2Eu^{2+}(aq) + Sn^{2+}(aq) \rightarrow 2Eu^{3+}(aq) + Sn(s)$
$E^0 = 0.43 - 0.14 = 0.29$ V

7.

(a) Standard conditions are:
one mol L^{-1} concentration of electrolytes, one atmospheric pressure, and a temperature of 25°C.

(b) $Fe^{2+} + 2e^- \rightarrow Fe$ -0.44V
$Mg^{2+} + 2e \rightarrow Mg$ -2.37V (reduction)
$Mg \rightarrow Mg^{2+} + 2\,e^-$ +2.37V (oxidation)

8.

(a) In order of increasing strength as oxidising agents:

$Cu^{2+}(aq) < O_2(g) < Cr_2O_7^{2-}(aq) < Cl_2(g) < H_2O_2(aq)$

(b) *In order of increasing strength as reducing agents:*

$Al < Zn < Sn < I^- < H_2O_2$

9. *The critical variable for spontaneous reactivity is E°.*

(a) *E° Positive, spontaneous*

(b) *E° Positive, spontaneous*

(c) *E° Negative, not spontaneous*

(d) *E° Negative, not spontaneous*

10. *Applying Le Châtelier's principle, any change that shifts the equilibrium to the left will make the reaction less spontaneous, and so will decrease E°.*

(a) *No effect* (b) *No effect*

(c) *Decreases E°* (d) *Decreases E°*

11.

(a) *Physical contact between the two different phases*

(b) *An inert electrode*

(c) *A salt bridge or a porous separator*

12.

(a) $Cr_2O_7^{2-}$

(b) Ni^{2+}

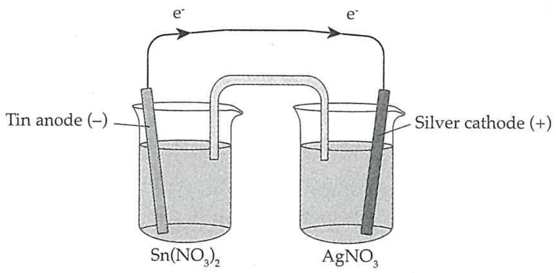
(c) Cr^{3+}

13.

(a) $Sn \rightarrow Sn^{2+} + 2e^-$ +0.14 V

$2Ag^+ + 2e^- \rightarrow 2Ag$ +0.80 V

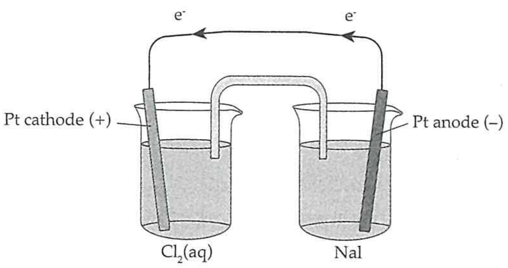
$Sn + 2Ag^+ \rightarrow Sn^{2+} + 2Ag$ +0.94 V



(b) $Cl_2 + 2e^- \rightarrow 2Cl^-$ +1.36 V

$2I^- \rightarrow I_2 + 2e^-$ -0.54 V

$Cl_2 + 2I \rightarrow 2Cl^- + I_2$ +0.82 V



(c) $Fe/Fe^{2+}//\ Sn^{4+}/Sn^{2+}$ -0.44 V +0.15 V

$Fe \rightarrow Fe^{2+} + 2e^-$ +0.44 V

$Sn^{4+} + 2e^- \rightarrow Sn^{2+}$ +0.15 V

$Fe + Sn^{4+} \rightarrow Fe^{2+} + Sn^{2+}$

+0.59 V

14.

(a) *Anode* $Cd(s) \rightarrow Cd^{2+} + 2e^-$

Cathode $Ni^{3+} + e^- \rightarrow Ni^{2+}$

(b) *Anode* $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

Cathode $Ag^+ + e^- \rightarrow Ag$

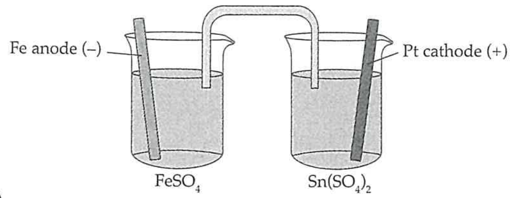
15.

(a) *Anode:* $Fe \rightarrow Fe^{2+} + 2e-$

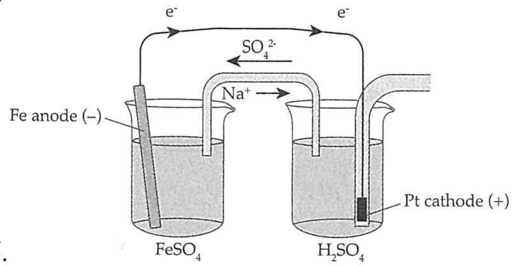
Iron rod will be the anode.

(b) $2H^+ + 2e^- \rightarrow H_2$

Platinum provides the reacting surface and is the cathode.



(c)



16.

(a) *Anode reaction:* $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$

- 0.77 V

(b) *Cathode reaction:* $Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$

+1.07 V

Cell potential: +0.30 V

(c) *Platinum cathode is labelled positive as it receives negative charges.*

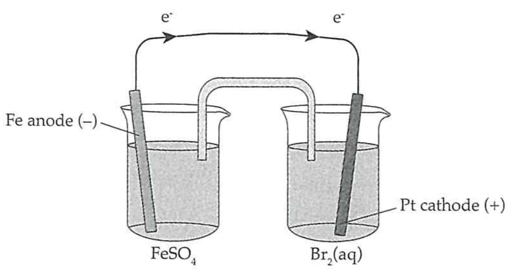
(d) *Iron anode is labelled negative as it releases negative charges.*

(e) *Bromide ions migrate towards the iron anode.*

(f) *Electrons flow from Fe anode to Platinum cathode.*

(g) *0.30 V.*

(h) *A reaction is obvious as the colour of bromine in the cathode half-cell fades, as bromine is reduced to bromide ions.*



17.

(a) *Looking at the electrode potentials, HCl does not react with copper. HCl does react with zinc.*

$Cu \rightarrow Cu^{2+} + 2e^-$ -0.34 V

$Zn \rightarrow Zn^{2+} + 2e^-$ +0.76 V

$2H^+ + 2e^- \rightarrow H_2$ 0.00 V

$Cu + 2H^+ \rightarrow Cu^{2+} + H_2$ -0.34 V
$Zn + 2H^+ \rightarrow Zn^{2+} + H_2$ +0.76 V
Reaction does not occur – E^0 negative.
Reaction does occur – E^0 positive.

(b) *The fall in concentration of sulfuric acid means the battery is not recharging adequately to restore the sulfuric acid. This is indicated by the hydrometer that is used to measure the density of the electrolyte. Recharging using the mains current with a battery charger, or replenishing the battery with fresh sulfuric acid should restore the higher concentration of the electrolyte.*

18.

(a) *The NO_3^- species does not react with other chemicals in the cell but Cl^- can be oxidised to Cl_2.*

(b) *Being spectator species in the salt bridge, they are better able to maintain ionic equilibrium between the anode and the cathode half cells, i.e. can transfer charge.*

(c) *The chloride ions tend to get preferentially oxidised and will interfere with the reactions for which the cell is designed. With silver, a precipitate would be formed.*

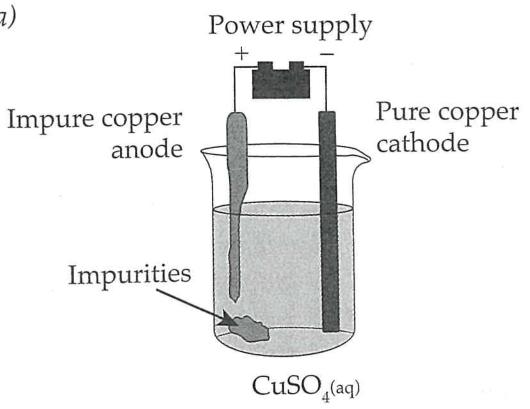
19.

(a) *For an ethanol fuel cell:*
The reactions in an acid environment are as follows:
Anode reaction:
$CH_3CH_2OH + 3H_2O \rightarrow 2CO_2 + 12H^+ + 12e^-$
Cathode reaction:
$3O_2 + 12H^+ + 12e^- \rightarrow 6H_2O$

(b) *The reactions in an acid environment are as follows:*
Anode reaction:
$CH_4 + 2H_2O \rightarrow CO_2 + 8H^+ + 8e^-$
The reactions in an acid environment are as follows:
Cathode reaction:
$2O_2 + 8H^+ + 8e^- \rightarrow 4H_2O$

20.

(a)



(b) *Anode:* $Cu_{(s)} \rightleftharpoons Cu^{2+}{}_{(aq)} + 2e^-$
Cathode: $Cu^{2+}{}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)}$

(c) $Cu_{(s)} \rightleftharpoons Cu^{2+}{}_{(aq)} + 2e^-$ $E^o = -0.34$ V
$Fe^{2+}{}_{(aq)} + 2e^- \rightleftharpoons Fe_{(s)}$ $E^o = -0.44$ V
Overall voltage required would be 0.34 + 0.44 = 0.78V
The voltage required to deposit iron on the cathode is only 0.78 V so the voltage must be kept below this.

(d) *Impurities like gold, silver and platinum will not be oxidised and as such will fall to the bottom of the cell as the anode slime to be recovered.*