Department of
Education and Training

TEACHER DEVELOPMENT CENTRE

Final Examination 2009 ANSWERS

CHEMISTRY 2A-2B

MULTIPLE CHOICE ANSWER SHEET

1. [A] **[B]** [C] [D]
2. [A] [B] **[C]** [D]
3. [A] [B] **[C]** [D]
4. **[A]** [B] [C] [D]
5. [A] [B] [C] **[D]**
6. **[A]** [B] [C] [D]
7. [A] [B] **[C]** [D]
8. [A] [B] [C] **[D]**
9. [A] [B] [C] **[D]**
10. **[A]** [B] [C] [D]
11. [A] **[B]** [C] [D]
12. [A] [B] **[C]** [D]
13. [A] [B] [C] **[D]**
14. **[A]** [B] [C] [D]
15. [A] [B] [C] **[D]**
16. [A] [B] **[C]** [D]
17. **[A]** [B] [C] [D]
18. [A] **[B]** [C] [D]
19. [A] [B] [C] **[D]**
20. [A] [B] [C] **[D]**
21. [A] [B] **[C]** [D]
22. [A] [B] **[C]** [D]
23. **[A]** [B] [C] [D]
24. [A] [B] **[C]** [D]
25. [A] **[B]** [C] [D]

(50 marks)

SECTION B

Question 1 *[8 marks]*

Write the equation for the reaction that occurs in each of the following procedures. If no reaction occurs write 'no reaction'.
Following this, describe **in full** what you would observe in each case, including any

- colours
- odours
- precipitates (give the colour)
- gases evolved (give the colour or describe as colourless).

If no change is observed, you should state this.

(a) Solid calcium hydrogencarbonate is added to 1.0mol L^{-1} Hydrochloric acid.

Equation: $Ca(HCO_3)_2(s) + 2H^+(aq) \longrightarrow H_2O + CO_2(g) + Ca^{2+}(aq)$

Observation: **White solid dissolves, bubble of colourless gas produced**

(b) Silver nitrate solution is added to sodium chloride solution.

Equation: $Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$

Observation: **White precipitate forms**

(c) A small piece of sodium metal is added to water.

Equation: $2Na(s) + 2H_2O \longrightarrow 2Na^+(aq) + 2OH^-(aq) + H_2(g)$

Observation: **Colourless gas is produced (which may ignite with a bang!)**

(d) Propene is shaken bromine water.

Equation: $C_2H_4 + Br_2 \longrightarrow C_2H_4Br_2$

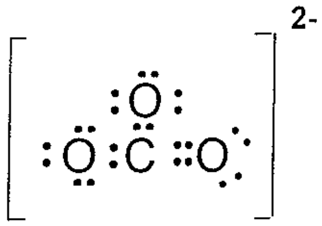
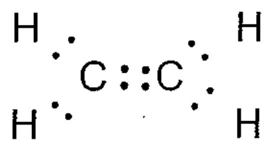
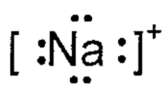
Observation: **Brown colour disappears**

Question 2 *[6 marks]*

Complete the following table by:

(a) Drawing electron dot diagrams for the species listed.

(b) Stating the type of bonding within the species drawn.

Species	Electron dot diagram	Type of bonding
CO_3^{2-}		Covalent
C_2H_4		Covalent
NaCl	 or: 	Ionic

Question 3 *[10 marks]*

In 1883 German chemist Dr Hans Goldschmidt discovered a highly reactive mixture called THERMITE.

Thermite is made by mixing iron oxide powder (Fe_2O_3) and aluminium powder, finely divided and thoroughly mixed. When ignited, an extremely exothermic reaction occurs producing molten iron and aluminium oxide.

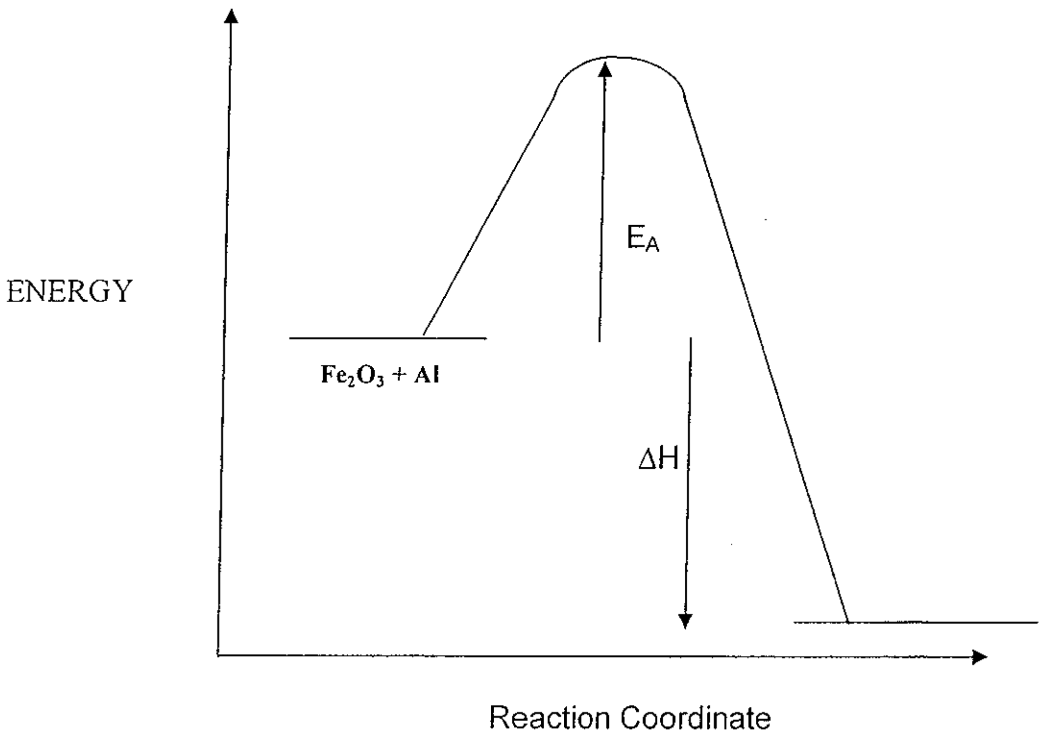
The first commercial application was the welding of tram tracks in 1899. It was recently used in the welding of tracks on the Perth to Mandurah railway line.

(a) Write a balanced chemical equation for this reaction *[1 mark]*

$$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe$$

ΔH for the reaction is -851.5 $kJmol^{-1}$,however, this reaction requires a very high activation energy to start. Dropping burning magnesium ribbon into the mixture is one way, since it burns at around 2200°C.

(b) On the following diagram, show the expected SHAPE of the reaction profile. Label the activation energy and the ΔH.



(c) The Fe_2O_3 and Al must be "finely divided" and thoroughly mixed. What does "finely divided" mean and why is this important?

[2 marks]

This means to make into a very fine powder. This greatly increases surface area which dramatically increases the rate of reaction.

(d) The Thermite reaction is a REDOX reaction. Identify the oxidant and reductant in the reaction:

[2 marks]

Oxidant: **Fe^{2+}** Reductant: **Al**

In order for the reaction to occur efficiently, the reactants must be mixed in the correct stoichiometric proportions, so there is no wasted excess of reactants.

(e) Calculate the mass of aluminium needed to completely react with 40g of Fe_2O_3.

[2 marks]

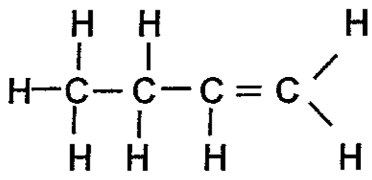
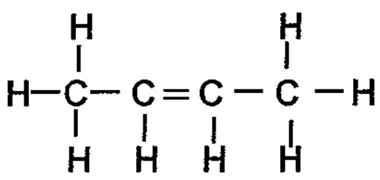
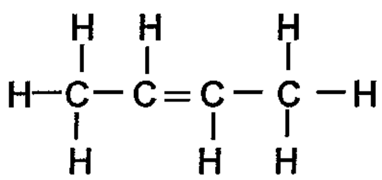
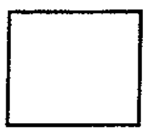
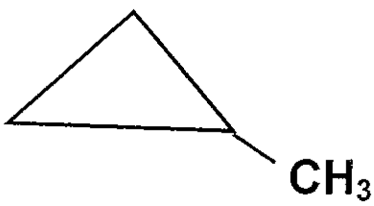
Moles Fe_2O_3 = 40/159.7 = 0.250 mol

From eq'n, moles Al = 0.500 mol

Mass Al = 0.500 x 26.98 = 13.49g

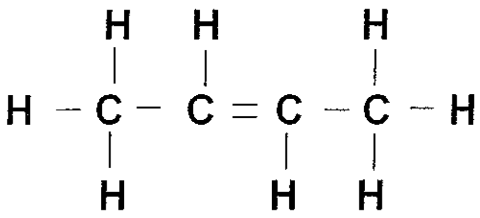
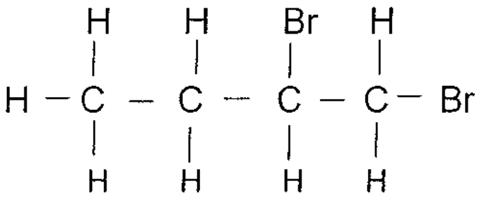
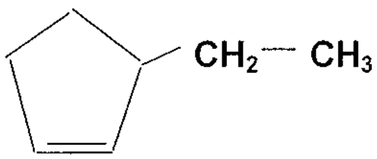
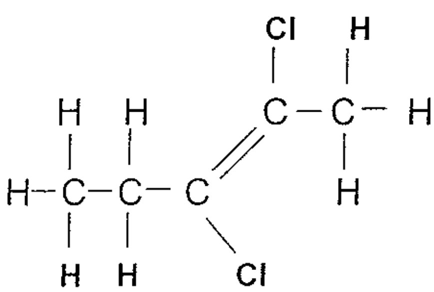
Question 4 *[8 marks]*

Draw 4 isomers for the compound C_4H_8, including two geometric isomers and one cyclic isomer. Using IUPAC nomenclature, name each isomer.

Structure	Name
	**1-butene**
	**Cis-2-butene**
	**Trans-2-butene**
 Or: 	**Cyclobutane** or **Methylcyclopropane**

Question 5 *[4 marks]*

Complete the table below by either naming or drawing the organic compound - whichever is missing.
When drawing compounds, use structural formulae and show all hydrogen atoms as appropriate.

Structure	IUPAC name
(a) 	Trans-2-butene
	(b) **1,2-dibromobutane**
(c) 	3-ethylcyclo-1-pentene
	(d) **Trans-2,3-dichloro-2-pentene**

Question 6

[6 marks]

When the acid concentration of the gastric juices in a person's stomach becomes too high, pain results. Taking "antacid" medicine neutralises the acid and relieves this pain.

(a) A person experiencing stomach pain may have gastric juice with a pH of 2.0. If the volume of gastric juice was 4.00 x10^2 mL, calculate the moles of acid in the stomach.

[2 marks]

$[H^+]$ = 1.0 x10^{-2} mol L^{-1}

Moles H^+ = 1.0 x10^{-2} x 0.400 = 4.0 x 10^{-3} mol

To neutralise this acid, a person dissolved some "bicarbonate of soda" (sodium hydrogen carbonate) in a glass of water and drank it.

(b) Write the ionic equation for this neutralisation reaction:

$HCO_3^-(aq) + H^+(aq) \longrightarrow H_2O(l) + CO_2(g)$

[1 mark]

(c) Calculate the minimum mass of sodium hydrogen carbonate which would need to be taken to ensure complete neutralisation of the stomach acid.

[3 marks]

Moles $NaHCO_3$ = 4.0 x 10^{-3} = 4 x 10^{-3} mol

Mass = 4 x 10^{-3} mol x 84 = 336 x 10^{-3}g = 0.336g

Question 7 *[9 marks]*

Write balanced half equations and the full redox equation for the following reactions.

(a) $Fe^{2+}{}_{(aq)}$ and $MnO_4^-{}_{(aq)}$ reacted together in acidic solution to form $Fe^{3+}{}_{aq)}$ and $MnO_{2(s)}$.

(i) **Oxidation half-equation:**

$$Fe^{2+}(aq) \longrightarrow Fe^{3+}(aq) + e^-$$

[1 mark]

(ii) **Reduction half-equation:**

$$MnO_4^-(aq) + 4H^+(aq) + 3e^- \longrightarrow MnO_2(s) + 2H_2O$$

[1 mark]

(iii) **Overall Redox Reaction:**

$$MnO_4^-(aq) + 4H^+(aq) + 3Fe^{2+}(aq) \longrightarrow MnO_2(s) + 2H_2O + Fe^{3+}(aq)$$

[1 mark]

(b) The reduction of nitrate ions in acidic solution with solid magnesium, forming Mg^{2+} ions and nitrogen II oxide (NO).

(i) **Oxidation half-equation:**

$$Mg(s) \longrightarrow Mg^{2+}(aq) + 2e^-$$

[1 mark]

(ii) **Reduction half-equation:**

$$NO_3^- + 4H^+(aq) + 3e^- \longrightarrow NO(g) + 2H_2O$$

[1 mark]

(iii) **Overall Redox Reaction:**

$$2NO_3^- + 8H^+(aq) + 3\,Mg(s) \longrightarrow 2NO(g) + 4H_2O + 3Mg^{2+}(aq)$$

[1 mark]

(c) Complete the table by identifying the oxidant in each reaction: *[3 marks]*

	reactions	oxidant
(i)	$Ca(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2(g)$	H^+
(ii)	$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$	Fe_2O_3
(iii)	$2NO_2(g) + H_2O(l) \rightarrow HNO_2(aq) + HNO_3(aq)$	NO_2 (Disprop'n)

Question 8 *[5 marks]*

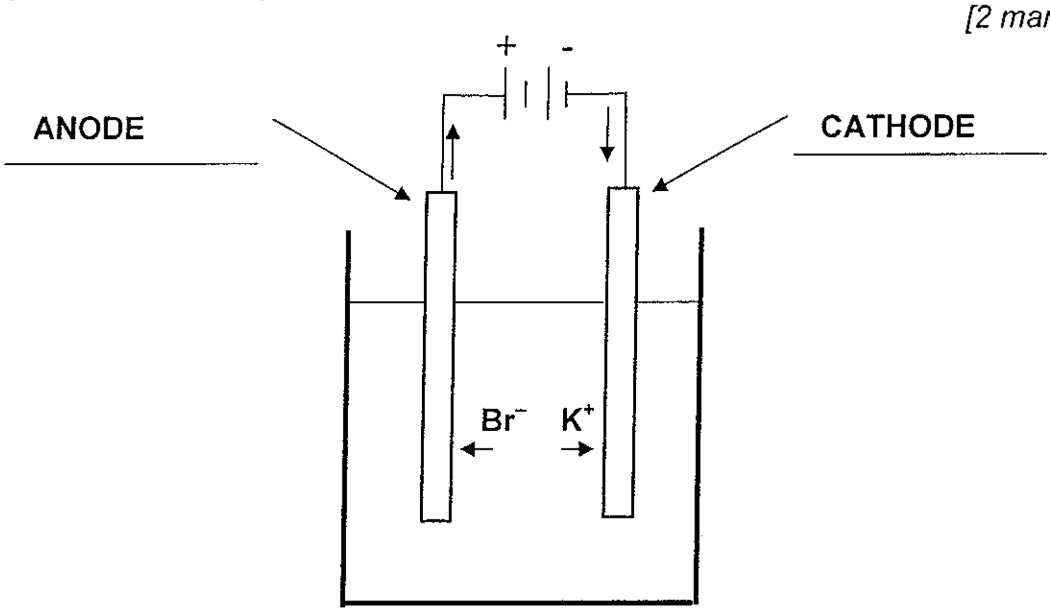
A sample of molten potassium bromide is electrolysed in an electrolytic cell.

(a) In the diagram below, label the following:
  (i) The direction of travel of electrons in the external circuit
  (ii) The anode and cathode
  (iii) The direction of travel of the potassium and bromide ions

[3 marks]

(b) Write the half equation for the reaction at each electrode.

[2 marks]



Equation:

$2Br^-(aq) \longrightarrow Br_2(aq) + 2e^-$

Equation:

$K^+(aq) + e^- \longrightarrow K(l)$

Question 9 *[4 marks]*

In the process of electro-refining, an impure metal can be purified using electrolysis. Below is a partially completed diagram to show how copper can be electro- refined.

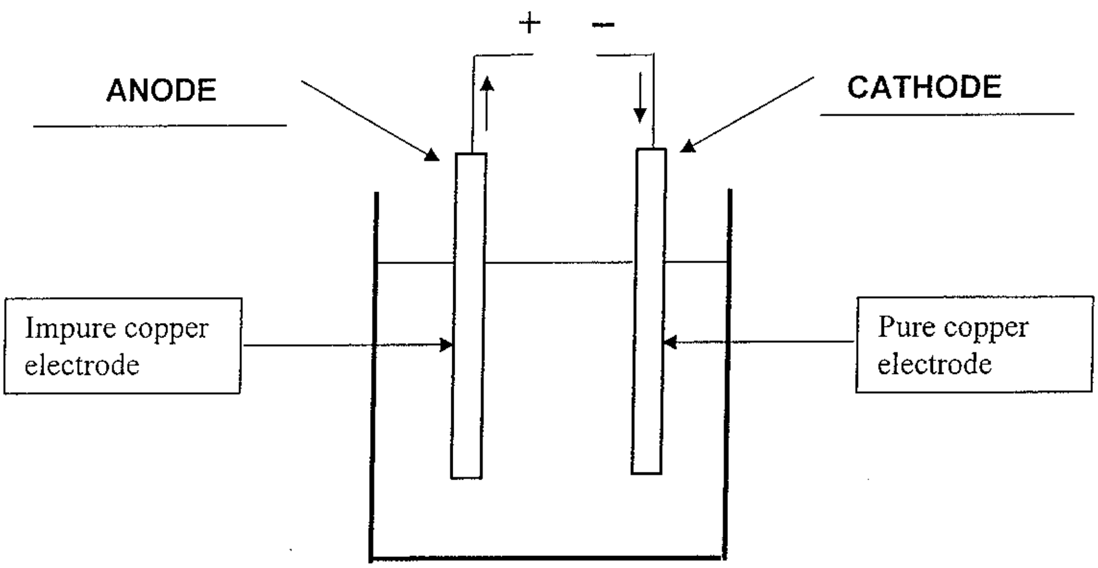
(a) Complete the diagram by showing:

(i) the polarity of the power supply (use + or – symbols) necessary for the cell to work properly.

(ii) the direction of travel of electrons in the external circuit.

(iii) and by labelling the anode and cathode.

[3 marks]



(b) Write the half equation for the reaction at the cathode:

$Cu^{2+}(aq) + 2e^{-} \longrightarrow Cu(s)$

[1 mark]

SECTION C

Question 1 *[10 marks]*

7.80 g of a pure liquid compound containing carbon, hydrogen and oxygen, on combustion, produced 11.44 g of carbon dioxide and 4.68 g of water.

(a) Determine the empirical formula of the compound.

[6 marks]

Moles CO_2 = 11.44g / 44 = 0.26 mole = moles of C (1)

Moles H_2O = 4.68 / 18 = 0.26 mol

Moles of H = 0.52 mol (1)

Mass of H and C in compound = 0.26 x 12 + 0.52 x 1 = 3.64g (1)

Mass of O in compound = 7.80 – 3.64 = 4.16g.

Moles of O = 4.16 / 16 = 0.26 mol (1)

C	H	O	
0.26	**0.52**	**0.26**	**(1)**
1	**2**	**1**	

Hence empirical formula is CH_2O (1)

Further analysis of the compound determined that its molar mass was 60.1 g mol^{-1}.

(b) Determine the molecular formula of the compound.

[2 marks]

1 mole = 30g for empirical formula

Molar mass is 60 so molecular formula is $C_2H_4O_2$

(c) The compound was found to react as a weak acid. What could be the name of this acid and write its structural formula. *[2 marks]*

Name: **Ethanoic acid/acetic acid/vinegar**

CH_3COOH

Question 2 *[8 marks]*

105 mL of a 0.500 molL-1 solution of potassium iodide was added to 50.0 mL of a solution containing 0.75 molL-1 of lead nitrate. A yellow precipitate results.

(a) Write a balanced ionic equation for this reaction

$$Pb^{2+} + 2I^{-} \rightarrow PbI_2$$

[1 mark]

(b) Determine the limiting reagent and hence identify the substance in excess.
[3 marks]

Mole KI = 0.5 x 0.105 = 0.0525 mol which needs 0.02625 mol $Pb(NO_3)_2$

Mole $Pb(NO_3)_2$ = 0.75 x 0.050 = 0.0375 mol which needs 0.075 mol KI

Hence limiting reagent is KI

(c) Calculate the mass of lead iodide produced. *[2 marks]*

Moles of KI used = 0.0525 mol
Hence moles PbI_2 = 0.02625 mol

Mass = 0.02625 x 461 = 12.1g

(d) Calculate the mass of the excess reagent. *[2 marks]*

Moles $Pb(NO_3)_2$ used = 0.02625 mol

Moles $Pb(NO_3)_2$ left = 0.0375 - 0.02625 = 0.01125 mol

Mass = 269.2 x 0.01125 = 3.03g

Question 3 *[12 marks]*

In the Haber process, ammonia is produced according to the reaction:

$$N_{2\,(g)} + 3\,H_{2\,(g)} \rightarrow 2\,NH_{3\,(g)}$$

The hydrogen gas is produced in two steps:
Firstly, methane is reacted with steam (H_2O) over a catalyst of NiO to produce carbon monoxide and hydrogen. The carbon monoxide then further reacts with steam to produce carbondioxide and hydrogen.

(a) Write and balance the two equations for this process: *[2 marks]*

$$\mathbf{CH_4 + H_2O \rightarrow CO + 3H_2}$$

$$\mathbf{CO + H_2O \rightarrow CO_2 + H_2}$$

(b) If $1.00\text{x}10^3$ kg of methane is reacted in excess steam, calculate the mass of hydrogen gas produced. *[3 marks]*

Moles methane = $1.00\text{x}10^6$ g / 16 = 6.25 x 104 moles

1 mole methane makes 4 moles H_2 = 2.50×10^5 mole produced

Mass of H_2 = 5.00×10^5 g = 500kg

(c) Calculate the mass of nitrogen gas required to completely react with the hydrogen gas [as calculated in (b)] to produce ammonia. *[2 marks]*

Moles N_2 = $2.50 \times 10^5 / 3$ = 8.33×10^4 mol

Mass N_2 = $8.33 \times 10^4 \times 28.02 = 2.335 \times 10^6$ = 2335kg

The mole ratio of oxygen to nitrogen in air can be considered to be 4 to 1. When air is added to the system, the oxygen reacts with hydrogen at a high temperature leaving nitrogen gas:

$$2\,H_{2(g)} + [O_{2(g)} + 4N_{2(g)}] \rightarrow 2H_2O_{(g)} + 4N_{2(g)}$$

(air)

(d) Calculate the mass of hydrogen gas required to produce amount of nitrogen gas as calculated in (c). *[2 marks]*

Moles N_2 = 8.33×10^4 mol so moles H_2 needed = 4.165×10^4 mol

Mass H_2 = 2 x 4.165×10^4 mol = 8.33×10^4 g = 83.3kg

(If $2.00\text{x}10^3$ kg is used, answer is 71.35kg)

In practice, not all the hydrogen and nitrogen react completely. In a particular factory, a yield of only 40% is achieved.

(e) Calculate the mass of ammonia produced from the quantities of nitrogen and hydrogen you have determined.

[3 marks]

1 mole N_2 makes 2 mole NH_3, so for 100% yield,
So moles NH_3 = 2 x 8.33 x 10^4 mol = 1.667 x 10^5mol

For 40% yield, mass of NH_3 = 40/100 x 1.667 x 10^5mol x 17.01
= 1.134 x10^6 g
= 1130 kg

Question 4 *[10 marks]*

The sea level rise that followed the last ice age inundated coastal bays and rivers. The sulfate in the sea water combined with organic matter and reduced iron minerals to form iron sulfide minerals (Pyrites – FeS_2).

The production of pyrite requires a supply of sulfate, easily decomposable organic matter (CH_2O), oxygen and iron rich sediments. The overall reaction for pyrite production is:

$$Fe_2O_3(s) + 4SO_4^{2-}(aq) + 8CH_2O(s) + 1/2\ O_2(aq) \rightarrow 2\ FeS_2(s) + 8HCO_3^-(aq) + 4H_2O(l)$$

a) Identify ALL the oxidising and reducing agents in this equation

[3 marks]

Oxidising agents: SO_4^{2-}, O_2

Reducing agents: Fe_2O_3, CH_2O

b) What is unusual about this redox reaction compared to many that you may have come across in your studies?

[1 mark]

There are 2 oxidising agents and 2 reducing agents

The pyrite reacts with oxygen and soil moisture to produce iron (III) hydroxide ($Fe(OH)_3$), sulfate ions (SO_4^{2-}), and hydrogen ions (H^+), according to the equation for the reaction:

$$4FeS_2(s) + 15O_2(aq) + 14H_2O(l) \rightarrow 4Fe(OH)_3(s) + 8SO_4^{2-}(aq) + 16H^+(aq)$$

At pH greater than 4, Fe^{3+} ion is unstable and the precipitate $Fe(OH)_3$ is formed. Name the acid that's going to be produced in the soil, and state its nature?

[1 mark]

Sulphuric Acid which is a Strong Acid

If the pH is below 4, however, ferric iron remains stable and may further oxidise pyrite according to this equation:

$$FeS_2(s) + 14Fe^{3+}(aq) + 8H_2O(l) \rightarrow 15Fe^{2+}(aq) + 2SO_4^{2-}(aq) + 16H^+(aq)$$

This reaction is notable as it means that iron III ions may oxidise pyrite in the absence of oxygen, away from the groundwater-air interface.

Environmentalists have suggested that the pits left from mining be filled with water to create natural wetlands for wildlife aquaculture and recreation. You are a chemist and asked your opinion on the wisdom of this proposal. Use the information and equations above in your advice to this proposal.

[5 marks]

- **On exposure to air the iron III oxide becomes reduced and the iron sulphide becomes further oxidised, producing sulphuric acid**

- **The water becomes increasingly acidic as runoff enters the artificial lake.**
- **As the water becomes more acidic (pH < 4) Fe3+ oxidises pyrites in the subsurface sediments, producing more sulphuric acid**
- **Because of the feedback mechanism water becomes increasingly acidic over time.**
- **Unsuitable for commercial, recreational or environmental uses.**

END OF EXAMINATION