Higher Chemistry

Chemistry In Society Unit 3

Homework Exercises

Oxidising and Reducing Agents, Ion-Electron and Redox Equations and Chemical Analysis

Exercise 1

Revision

Oxidation and Reduction

Decide whether each of the following reactions involve:

A: Oxidation B: Reduction

(You may wish to use your data book to help you)

a) $Zn^{2+}(aq) + 2e^- \longrightarrow Zn(s)$
b) $Ag(s) \longrightarrow Ag^+(aq) + e-$
c) $Br_2 + 2e^- \longrightarrow 2Br^-(aq)$
d) $Sn^{2+}(aq) + 2e^- \longrightarrow Sn(s)$
e) $2Cl^-(aq) \longrightarrow Cl_2(g)$
f) $Mg^{2+(}aq) \longrightarrow Mg(s)$
g) $Fe(s) \longrightarrow Fe^{2+}(aq)$
h) $SO_3^{2-(}aq) \longrightarrow SO_4^{2-}(aq)$
i) Nickel(III) ⟶ Nickel (II)
j) Cobalt (II) ⟶ Cobalt (III)
k) Copper Atoms ⟶ Copper Ions
l) Iodine Molecules ⟶ Iodide Ions

(TOTAL /12)

Exercise 2

<u>Oxidising and Reducing Agents – Part 1</u>

1. a) What is an oxidising agent?
   b) What is a reducing agent?

2. For the following reactions, identify whether each of the underlined reactants is acting as

A: An oxidising agent B: A reducing agent

a)	<u>$Zn(s)$</u>	+	$2H^+$	$\longrightarrow$	Zn^{2+}(aq)	+	$H_2(g)$
b)	<u>$Cl_2(g)$</u>	+	$2I^-(aq)$	$\longrightarrow$	$2Cl^-$	+	$I_2(aq)$
c)	<u>$Mg(s)$</u>	+	$Cu^{2+}(aq)$	$\longrightarrow$	$Mg^{2+}(aq)$	+	$Cu(s)$
d)	$Fe_2O_3(s)$	+	<u>$3CO$</u>	$\longrightarrow$	$2Fe(s)$	+	$2CO_2(g)$
e)	$2Mg(s)$	+	<u>UF_4</u>	$\longrightarrow$	$2MgF_2(aq)$	+	U

3. For the following reactions, identify which is the oxidising agent and which is the reducing agent.

a)	$Cl_2(g)$	+	$2Fe^{2+}(aq)$	$\longrightarrow$	$2Cl^-$	+	$2Fe^{3+}(aq)$
b)	$CuSO_4$	+	$Zn(s)$	$\longrightarrow$	$Cu(s)$	+	$ZnSO_4$
c)	$2AgNO_3(aq)$	+	$Ni(s)$	$\longrightarrow$	$Ni(NO_3)_2$	+	$2Ag(s)$
d)	$CuO(s)$	+	$CO(g)$	$\longrightarrow$	$Cu(s)$	+	$CO_2(g)$
e)	$2Al$	+	Fe_2O_3	$\longrightarrow$	Al_2O_3	+	$2Fe$

(TOTAL /12)

Exercise 3

Oxidising and Reducing Agents – Part 2

1. Electronegativity is a useful guide for predicting whether a substance will act as an oxidising agent or reducing agent.

Fluorine has an electronegativity of 4 which is high.

a. Will fluorine act as a strong oxidising agent or a strong reducing agent? Explain your answer.

(2)

Sodium has an electronegativity of 0.9 which is low.

b. Will sodium act as a strong oxidising agent or a strong reducing agent? Explain your answer.

(2)

2.

a. In which group are the best reducing agents in the periodic table? (1)
b. In which group are the best oxidising agents in the periodic table? (1)
c. Where on the electrochemical series will you find the strongest oxidising agents? (1)
d. Where on the electrochemical series will you find the strongest reducing agents (1)
e. Tabulate the following in order to categorise them as either oxidising or reducing agents:

Li	Cs	Zn	Na	Cl_2	Br_2
Fe^{3+}	Hg^{2+}	SO_3^{2-}	CO	MnO_4^-	$Cr_2O_7^{2-}$

(6)

f. Give an example of how an oxidising agent is used in everyday life. (1)

(TOTAL /15)

Exercise 4

Redox Reactions – Part 1

1. Decide whether each of the following reactions is:

A: Redox Reaction B: NOT a Redox reaction

a.	$Zn(s)$	+	$2H^{+}(aq)$	$\longrightarrow$	$Zn^{2+(}aq)$	+	$H_2(g)$
b.	$2NH_3(g)$			$\longrightarrow$	$N_2(g)$	+	$3H_2(g)$
c.	OH^{-}	+	H^{+}	$\longrightarrow$	H_2O		
d.	Ag^{+}	+	Cl^{-}	$\longrightarrow$	$AgCl(s)$		
e.	$SnCl_2$	+	$HgCl_2$	$\longrightarrow$	$Hg(l)$	+	$SnCl_4(aq)$
f.	$C_2H_4(g)$	+	$Br_2(g)$	$\longrightarrow$	$C_2H_4Br_2(l)$		
g.	$2FeO(s)$	+	$C(s)$	$\longrightarrow$	$2Fe(s)$	+	$CO_2(g)$
h.	$2Mg(s)$	+	$O_2(g)$	$\longrightarrow$	$2MgO(s)$		
i.	$Na_2SO_4(aq)$	+	$BaCl_2(aq)$	$\longrightarrow$	$2NaCl(aq)$	+	$BaSO_4(s)$
j.	$CuO(s)$	+	$2HNO_3(aq)$	$\longrightarrow$	$Cu(NO_3)_2(aq)$	+	H_2O
k.	$CaCO_3(s)$			$\longrightarrow$	$CaO(s)$	+	$CO_2(g)$
l.	$2Na_2S_2O_3(aq)$	+	$I_2(aq)$	$\longrightarrow$	$2NaI(aq)$	+	$Na_2S_4O_6(aq)$
m.	$2Na(s)$	+	$2H_2O(l)$	$\longrightarrow$	$2NaOH(aq)$	+	$H_2(g)$
n.	$2Fe(NO_3)_3(aq)$	+	$2KI$	$\longrightarrow$	$2Fe(NO_3)_2$	+	$KNO_3(aq) + I_2(aq)$

(TOTAL /14)

Exercise 5

Redox Reactions – Part 2

1. For each of the following reactions write an ion-electron equation for the oxidation and reduction.

Combine the oxidation and reduction reactions you have written to form the redox reactions

a. Sodium sulphite reduces iodine to iodide ions.
b. Potassium iodide reduces chlorine solution.
c. Potassium permanganate oxidises hydrochloric acid to chlorine.
d. In acid solution, potassium dichromate oxidises iron(II)sulphate to iron(III)sulphate.
e. In acid solution, potassium permanganate oxidises sodium bromide.
f. Zinc displaces silver form a solution containing silver(I) ions.

(TOTAL /12)

Exercise 6

Redox Reaction – Part 3

1. Write a balanced ion-electron equation for each of the following reactions.
   Check the answers to the first two in the data booklet.

a. $SO_3^{2-}(aq) \longrightarrow SO_4^{2-}(aq)$
b. $MnO_4^- \longrightarrow Mn^{2+}$
c. $XeO_3 \longrightarrow Xe$
d. $IO_3^-(aq) \longrightarrow I_2(aq)$
e. $PbO_2 \longrightarrow Pb^{2+}$ (5)

2. The ion-electron equations for a reaction are as follows. Combine these in order to produce a balanced redox equation.

   a. $Fe^{3+} + e^- \longrightarrow Fe^{2+}$
   $2I^- \longrightarrow I_2 + 2e^-$

   b. $Sn^{2+} \longrightarrow Sn^{4+} + 2e^-$
   $Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$

   c. $I_2 + 2e^- \longrightarrow 2I^-$
   $SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2e^-$

(3)

3. Copper atoms are oxidised to copper (II) ions.
   Nitrate ions are reduced to nitrogen monoxide, NO a colourless gas which forms brown fumes of Nitrogen dioxide in contact with air

   Write down the oxidation and reduction equation and write a balanced redox reaction for this. (2)

(TOTAL /10)

Exercise 7

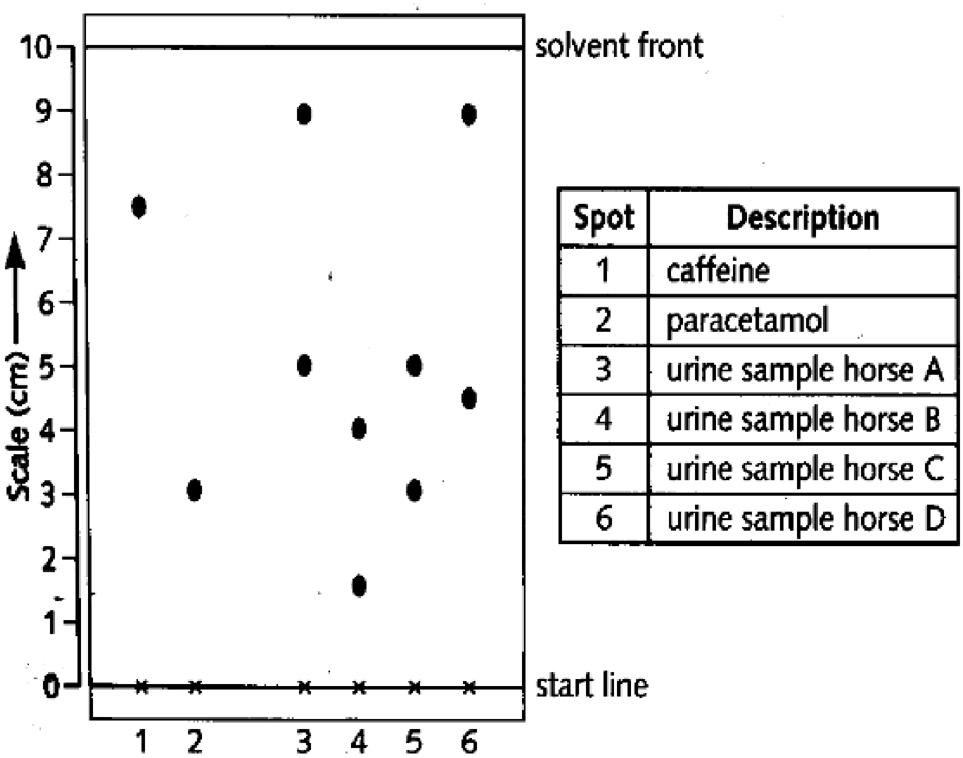
<u>Chromatography</u>

Chromatography is used in many analytical chemistry applications.

Thin-layer chromatography (TLC) uses a glass plate with a thin layer of silica gel dried onto to it in order to mount samples (A TLC plate).

This is used by the 'Horse Racing Forensic Laboratory' to test for the presence of illegal drugs in racehorses.

A concentrated sample of urine is spotted onto the TLC plate on the start line. Alongside this, known drugs are spotted. The chromatogram is run using methanol as the solvent. When finished, the paper is read by placing under ultra-violet light. A chromatogram of urine from four racehorses is shown.



Spot	Description
1	caffeine
2	paracetamol
3	urine sample horse A
4	urine sample horse B
5	urine sample horse C
6	urine sample horse D

1. a. The results for known drugs are given as 'R_f values'. Calculate the R_f value for

   i. Caffeine

   ii. Paracetamol

(2)

b. All chromatographic techniques involve a mobile phase and a stationary phase. For this application, identify:

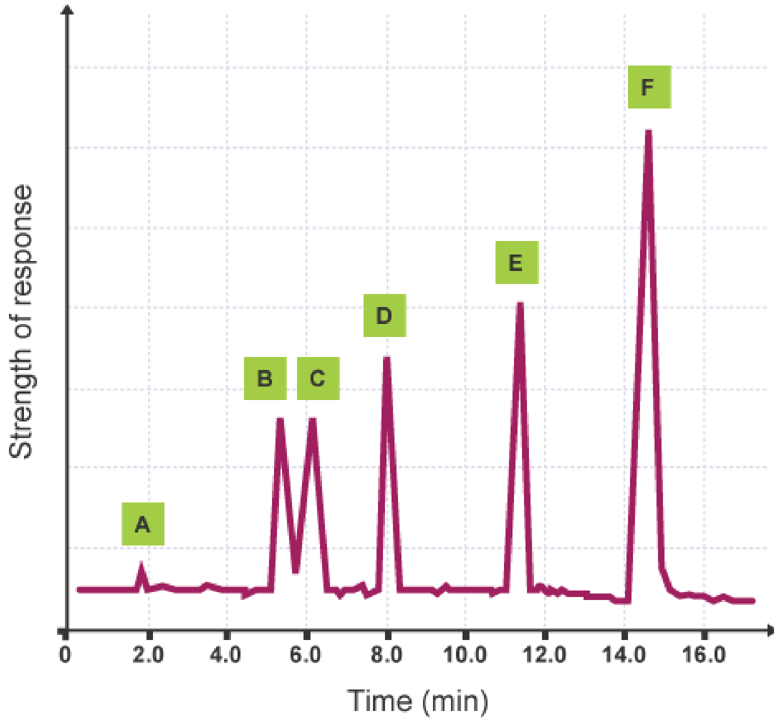
i. the mobile phase

ii. the stationary phase

(2)

c. State two factors which determine the distance a substance travels up the TLC plate. (2)

2. Consider the gas chromatogram below.



a. How many substances were identified as being in the sample?

b. Which substance had the shortest retention time?

c. Which two substances were present in the sample in equal amounts?

d. Which substance was present in the greatest quantity?

e. Which substance had the greatest affinity for the stationary phase?

(5)

(TOTAL/11)

Exercise 8

Volumetric Analysis

1. a. In volumetric analysis, what is a titration used for? (1)

   b. What is meant by the term end-point? (1)

   c. An indicator is a substance which changes colour at the end-point of a titration. Give an example of an indicator used in titrations. (1)

   d. Where might errors occur in titrations? Name 2. (2)

   e. What measures are taken in a titration to ensure accuracy and precision? (1)

   f. What is meant by a standard solution? (1)

   g. Explain how to make up a standard solution? (1)

2. a. What volume of hydrochloric acid (concentration 0.1 mol l^{-1}) is required to neutralise 100 cm^3 of sodium hydroxide solution (concentration 0.5 mol l^{-1})

$$HCl + NaOH \rightarrow NaCl + H_2O$$

(2)

   b. If 25 cm^3 hydrochloric acid is neutralised by 50 cm^3 of potassium hydroxide solution (concentration 2 mol l^{-1}), what is the concentration of the acid?

$$HCl + KOH \rightarrow KCl + H_2O$$

(2)

3. a. What volume of nitric acid (concentration 0.5 mol l^{-1}) is required to neutralise 25 cm^3 sodium hydroxide solution (concentration 0.4 mol l^{-1})? (2)

   b. What volume of sulphuric acid (concentration 2.5 mol l^{-1}) is required to neutralise 25 cm^3 of potassium hydroxide solution (concentration 4 mol l^{-1})? (2)

4. a. In a titration it was found that 10 cm^3 of potassium hydroxide was neutralised by 0.05 mol l^{-1} sulphuric acid. The volumes of sulphuric acid used in the titration were:

Titration	Volume of 0.05 mol l-1 sulphuric acid/cm3
1	18.0
2	17.4
3	17.3

Calculate the concentration of the potassium hydroxide given that potassium hydroxide reacts with sulphuric acid according to the equation below.

$$2KOH (aq) \quad + \quad H_2SO4(aq) \rightarrow \quad K_2SO4(aq) \quad 2H_2O$$

Exercise 9

Redox Titrations

1. Sugars, such as glucose, are often used as sweeteners in soft drinks.

   The glucose content of a soft drink can be estimated by titration against a standardised solution of Benedict's solution. The copper (II) ions in Benedict's solution react with glucose as shown:

   $C_6H_{12}O_6(aq) + 2Cu^{2+}(aq) + 2H_2O(l) \rightarrow Cu_2O(s) + 4H^+ + C_6H_{12}O_7(aq)$

   a. What change in the ratio of atoms present indicates that the conversion of glucose into the compound with molecular formula $C_6H_{12}O_7$ is an example of oxidation?
   b. In one experiment, 25.0 cm^3 volumes of a soft drink were titrated with Benedicts solution in which the concentration of copper (II) ions was 0.5 mol l^{-1}. The following results were obtained:

Titration	Volume of Benedict's (cm^3)
1	18.0
2	17.1
3	17.3

The average volume of Benedict's solution used was 17.2 cm^3.

i. Why was the first titration result not used in calculating the average volume of Benedict's solution?

ii. Calculate the concentration of glucose in the drink in mol l^{-1}.

2. Iron (II) ions react with dichromate ions in acidic solution.

$6Fe^{2+}$ (aq) + $Cr_2O_7^{2-}$ (aq) + $14H^+$(aq) → $6Fe^{3+}$(aq) + $2Cr^{2+}$(aq) + $7H_2O$(l)

Calculate the amount, in moles, of iron (II) ions which will react completely with 250 cm^3 of dichromate solution, concentration 0.1 mol l^{-1}.

3. Permanganate ions react with hydrogen peroxide in acidic solution.

$2MnO_4^-$(aq) + $6H^+$ + $5H_2O_2$(aq) → $2Mn^{2+}$(aq) + $8H_2O$(l) + $5O_2$(g)

25 cm^3 of hydrogen peroxide solution reacted with 16 cm^3 of permanganate solution, concentration 0.1 mol l^{-1}.

Calculate the concentration of hydrogen peroxide solution.

4. Dichromate ions react with ethanol in acidic solution.

$2Cr_2O_7^{2-}$(aq) + $3C_2H_5OH$(aq) + $6H^+$ → $3CH_3COOH$(aq) + $4Cr^{3+}$(aq) + $11H_2O$

It was found that 12.5 cm^3 of 0.1 mol l^{-1} potassium dichromate solution was required to oxidise the ethanol in a 1 cm^3 sample of wine.

Calculate the mass of ethanol in the 1 cm^3 wine sample.

5. The chlorine levels in a swimming pool can be determined by titrating samples against acidified iron (II) sulphate solution. The reaction taking place is:

Cl_2(aq) + $2Fe^{2+}$(aq) → $2Fe^{3+}$(aq) + $2Cl^-$(aq)

A 100 cm^3 sample of water from a swimming pool required 24.9 cm^3 of 2.82 x 10-4 mol l^{-1} iron (II) sulphate solution to reach the end point.

Calculate the chlorine concentration, in g l^{-1} in the swimming pool water.

6. In the experiment, to measure the concentration of ozone, O_3, in the air in a Scottish city, 105 litres of air were bubbled through a solution of potassium iodide. Ozone reacts with potassium iodide solution, releasing iodine.

$$2KI(aq) + O_3(g) + H_2O(l) \rightarrow I_2(aq) + O_2(g) + 2KOH(aq)$$

The iodine formed was oxidised by 22.5 cm^3 of 0.01 mol l^{-1} sodium thiosulphate solution using a starch indicator.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

a. What colour change would show the titration was complete?

b. Calculate the volume of ozone in one litre of air.
(Take the volume of one mole of ozone to be 24 litres).

7. The following relationship is used to calculate the percentage purity of a salt.

$$Percentage\ Purity = \frac{mass\ of\ pure\ salt}{mass\ of\ impure\ salt} \times 100$$

The percentage purity of iron (II) salts can be found by titration with acidified potassium permanganate solution.

Equations:

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

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

A pupil was given 1.55 g of impure iron(II)sulphate, $FeSO_4.7H_2O$, and used this to prepare 250 cm^3 of solution for the titration.

It was found that 9.5 cm^3 of 0.01 mol l^{-1} acidified potassium permanganate solution was required to oxidise 25 cm^3 of the iron (II) sulphate solution.

a. Why was an indicator not added to the iron(II)sulphate solution prior to the titration experiment?

b. Calculate the mass of pure iron (II) sulphate and thus find the percentage purity of the iron(II)sulphate salt?

Acknowledgements

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http://www.averyweigh-tronix.com/chemical-and-petrochemical, April 2014

2. Chemcord Chemistry Package

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4. BBC Bitesize (Gas Chromatograph Image), Accessed Online via: http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_21c/further_chemistry/chromatography/revision/6/, April 2014

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6. J. Anderson, E. Allan and J. Harris, Higher Chemistry for CfE, Hodder Gibson, Paisley, UK, 2012