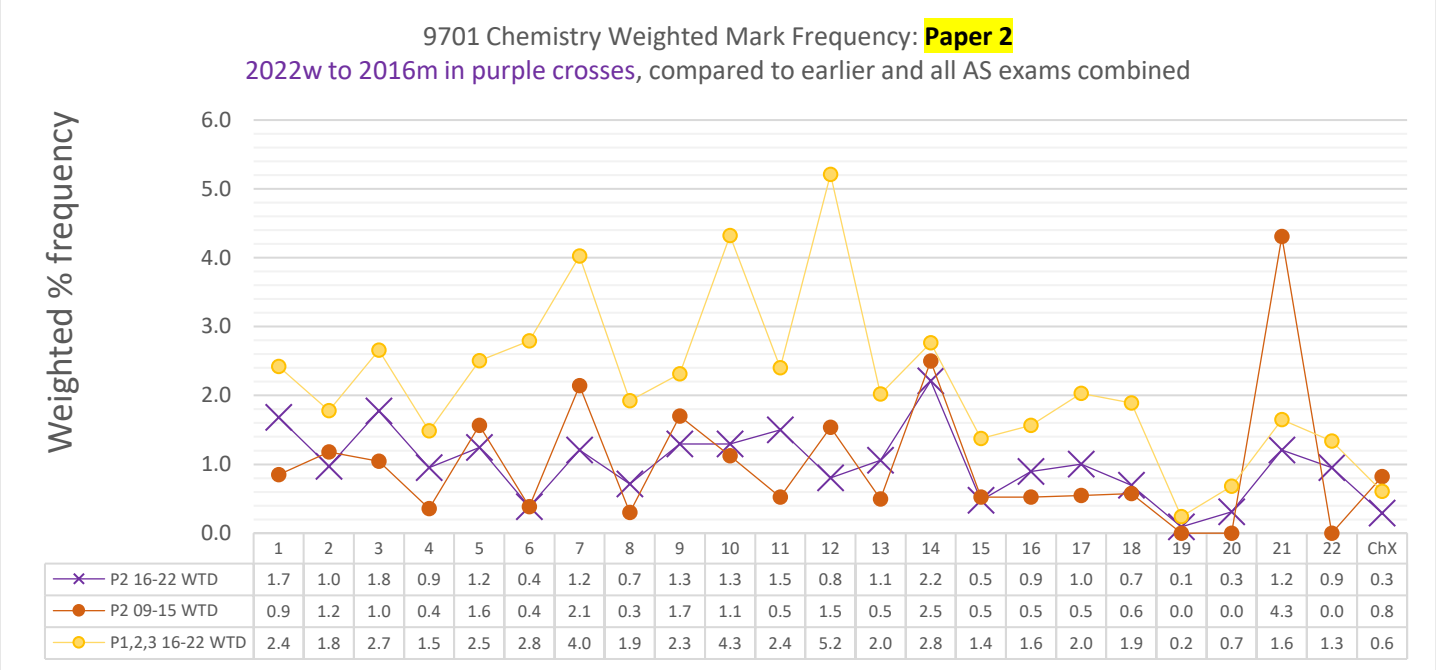
Name: Class: Date:

ALvl Chem 6 EQ P2 22w to 09s Paper 2 Electrochemistry 35marks

As you start and work through this worksheet you can tick off your progress to show yourself how much you have done, and what you need to do next. The first task is just to read the first question and should take you less than one minutes to complete.

Paper 2 Topic 6 Checklist Tick each task off as you go along

	RANK:	P1 Noob	P1 Novice	P1 Bronze	P1 Silver	P1 Gold	P1[1] Winner	P1 Hero	P1 Legend
		1 Q started	1 Q done	10% of marks	25% of marks	40% of marks	50% of marks	75% of marks	100% of marks
Topic (marks)	35		4	4	9	14	18	26	35
Time @75s/mark (minutes)	44		4	4	11	18	22	33	44



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	ChX
P2 16-22 WTD	1.7	1.0	1.8	0.9	1.2	0.4	1.2	0.7	1.3	1.3	1.5	0.8	1.1	2.2	0.5	0.9	1.0	0.7	0.1	0.3	1.2	0.9	0.3
P2 09-15 WTD	0.9	1.2	1.0	0.4	1.6	0.4	2.1	0.3	1.7	1.1	0.5	1.5	0.5	2.5	0.5	0.5	0.5	0.6	0.0	0.0	4.3	0.0	0.8
P1,2,3 16-22 WTD	2.4	1.8	2.7	1.5	2.5	2.8	4.0	1.9	2.3	4.3	2.4	5.2	2.0	2.8	1.4	1.6	2.0	1.9	0.2	0.7	1.6	1.3	0.6

What the most thoughtful students will get out of their extensive studying will be a capacity to do meaningful brain-based work even under stressful conditions, which is a part of the self-mastery skillset that will continue to deliver value for the whole of their lives. Outstanding grades will also happen, but the most important goal from skillful action in study is being better at any important task, even if circumstances do not feel ideal.

As you are moving through your studies you can learn more about yourself by trying out new ways to manage yourself, and analysing how effective those new techniques were. In this reflective process not only will you get better at working positively and productively to deliver ambitious and successful outcomes, but you will be working towards one aspect of life's highest pursuit, summarised and inscribed on the Temple of Apollo at Delphi: "know thyself".

1. To complete these questions, as important as your answer, is checking your answer against the mark scheme.
2. For each page or group of 10-20 marks, convert your mark score into a percentage. This will allow you to see (and feel) your progress as you get more experience and understanding with each topic.
3. Multiple choice questions, done carefully where you explain and show yourself your thinking using written notes as you move through each question, can be more useful than just Paper 2 for students aiming for a C or B grade. Paper 2 should be the larger focus for students aiming for A and A* grades, however.
4. If you find you get a higher percentage answering short answer questions than multiple choice questions that often means you are NOT using the marking scheme correctly; your correct answer might not be fully complete for all the marks you are awarding. The marks easiest to miss rely on providing the largest amount of detail.

[1] **DO NOT** work on these higher levels of completion in your AS year unless you have also achieved at least a "**Silver**" (25%) in the same topic in **Paper 1**, which tend also to be easier questions, as well as ""**Silver**" (25%) in the same topic, if it exists, in Paper 3.

6 Electrochemistry

6.1 Redox processes: electron transfer and changes in oxidation number (oxidation state)

Learning outcomes

Candidates should be able to:

1 calculate oxidation numbers of elements in compounds and ions
2 use changes in oxidation numbers to help balance chemical equations
3 explain and use the terms redox, oxidation, reduction and disproportionation in terms of electron transfer and changes in oxidation number
4 explain and use the terms oxidising agent and reducing agent
5 use a Roman numeral to indicate the magnitude of the oxidation number of an element

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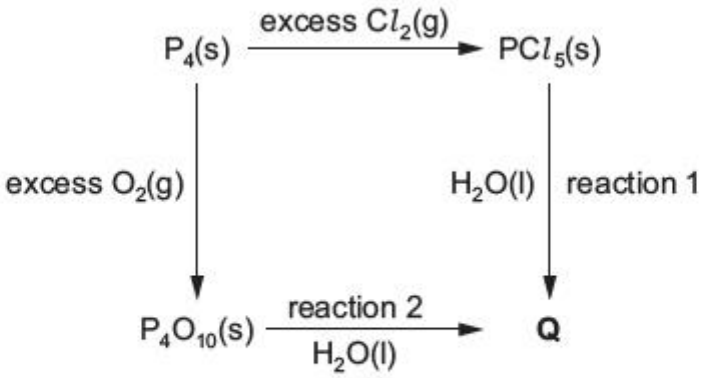
(b) Some reactions of $P_4(s)$ are shown in the reaction scheme.



(i) State the oxidation number of phosphorus in P_4O_{10}.

..... [1]

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(iii) $H_2S(aq)$ reacts slowly with oxygen dissolved in water. The reaction is represented by the following equation.

$$H_2S(aq) + \tfrac{1}{2}O_2(aq) \rightarrow H_2O(l) + S(s)$$

Explain, with reference to oxidation numbers, why this reaction is a redox reaction.

.....

.....

.....

..... [2]

Q# 136/ ALvl Chemistry/2020/s/TZ 1/Paper 4/Q# 2/www.SmashingScience.org

2 (a) The equation shown in **(a)(i)** describes the reaction which occurs when aqueous potassium iodide is added to aqueous copper(II) sulfate. A white precipitate of copper(I) iodide forms in a brown solution of iodine and potassium sulfate.

(i) Balance the equation and include state symbols.

.....$CuSO_4$(.....) + ...KI(.....) → .....CuI(.....) + ...I_2(.....) + ...K_2SO_4(.....)

[2]

The table gives the oxidation numbers of iodine in the different species in the equation.

iodine-containing species	oxidation number of iodine
KI	–1
CuI	–1
I_2	0

(ii) Deduce the oxidation number of copper in $CuSO_4$ and CuI.

- oxidation number of copper in $CuSO_4$ .....
- oxidation number of copper in CuI .....

[1]

(iii) Describe the type of reaction shown by the equation in **(a)(i)**. Explain your answer in terms of electron transfer.

.....

.....

..... [2]

Q# 137/ ALvl Chemistry/2019/w/TZ 1/Paper 4/Q# 1/www.SmashingScience.org

1 **(a)** Chlorine can be prepared using the following reaction.

$$MnO_2(s) + 4HCl(aq) \rightarrow MnCl_2(aq) + 2H_2O(l) + Cl_2(g)$$

(i) Explain why $MnO_2(s)$ is described as an oxidising agent in this reaction.

Refer to oxidation numbers in your answer.

.....

..... [1]

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1 Iron pyrite, FeS_2, has a yellow colour that makes it look like gold metal. The compound contains the ions Fe^{2+} and S_2^{2-}.

(ii) Calculate the oxidation number of sulfur in the S_2^{2-} ion.
Assume that each sulfur atom in the ion has the same oxidation number.

oxidation number of sulfur in the S_2^{2-} ion = ... [1]

Q# 139/ ALvl Chemistry/2017/m/TZ 2/Paper 4/Q# 1/www.SmashingScience.org

1 **(a)** The table shows information about some of the elements in the third period.

element	Na	Mg	Al	P	S	Cl
atomic radius / nm	0.186	0.160	0.143	0.110	0.104	0.099
radius of most common ion / nm	0.095	0.065	0.050	0.212	0.184	0.181
maximum oxidation number of the element in its compounds	+1					+7

(i) Complete the table to show the maximum oxidation number of each element in its compounds. [1]

Q# 140/ ALvl Chemistry/2016/m/TZ 2/Paper 4/Q# 2/www.SmashingScience.org

2 Spathose is an iron ore that contains iron(II) carbonate, $FeCO_3$. The percentage of iron(II) carbonate in spathose can be determined by titration with acidified potassium dichromate(VI) solution using a suitable indicator.

The ionic equation is shown below.

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

(a) A 5.00 g sample of spathose was reacted with excess concentrated hydrochloric acid and then filtered.
The filtrate was made up to 250 cm^3 in a volumetric flask with distilled water.

A 25.0 cm^3 sample of the standard solution required 27.30 cm^3 of 0.0200 mol dm^{-3} dichromate(VI) solution for complete reaction.

(i) Calculate the amount, in moles, of dichromate(VI) ions used in the titration.

amount = ... mol [1]

(ii) Use your answer to **(i)** to calculate the amount, in moles, of Fe^{2+} present in the 25.0 cm^3 sample.

amount = ... mol [1]

(iii) Use your answer to **(ii)** to calculate the amount, in moles, of Fe^{2+} present in the 250 cm^3 volumetric flask.

amount = ... mol [1]

(iv) Use your answer to **(iii)** to calculate the mass of iron(II) carbonate present in the sample of spathose.

mass = ... g [2]

(v) Calculate the percentage of iron(II) carbonate in the sample of spathose.

percentage of iron(II) carbonate = ... % [1]

(b) Iron ores containing iron(III) compounds can be analysed using a similar method.

A standard solution of an aqueous iron(III) compound is reacted with aqueous tin(II) chloride. Aqueous tin(IV) chloride and aqueous iron(II) chloride are the products of this reaction.

(i) Write an **ionic** equation for this reaction. Do not include state symbols.

..... [2]

(ii) Any excess tin(II) chloride can be removed by reaction with $HgCl_2(aq)$. A white precipitate of Hg_2Cl_2 is produced.

Complete the equation for this reaction.

.....(.....) + ...$HgCl_2(aq)$ → $SnCl_4$(.....) + Hg_2Cl_2(.....)

[2]

[Total: 10]

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(c) A compound of barium, **A**, is used in fireworks as an oxidising agent and to produce a green colour.

(i) Explain, in terms of electron transfer, what is meant by the term *oxidising agent*.

.....

..... [1]

2 The commonest form of iron(II) sulfate is the heptahydrate, $FeSO_4.7H_2O$. On heating at 90 °C this loses **some** of its water of crystallisation to form a different hydrated form of iron(II) sulfate, $FeSO_4.xH_2O$.

3.40 g of $FeSO_4.xH_2O$ was dissolved in water to form 250 cm^3 of solution.

A 25.0 cm^3 sample of this solution was acidified and titrated with 0.0200 mol dm^{-3} potassium manganate(VII).

In this titration 20.0 cm^3 of this potassium manganate(VII) solution was required to react fully with the Fe^{2+} ions present in the sample.

(a) The MnO_4^- ions in the potassium manganate(VII) *oxidise* the Fe^{2+} ions in the acidified solution.

(i) Explain, in terms of electron transfer, the meaning of the term *oxidise* in the sentence above.

.....

..... [1]

(ii) Complete and balance the ionic equation for the reaction between the manganate(VII) ions and the iron(II) ions.

$MnO_4^-(aq) + 5Fe^{2+}(aq) + ...H^+(aq) \rightarrow .....(aq) + 5Fe^{3+}(aq) + ...H_2O(l)$

[3]

(b) **(i)** Calculate the number of moles of manganate(VII) used in the titration.

[1]

(ii) Use the equation in **(a)(ii)** and your answer to **(b)(i)** to calculate the number of moles of Fe^{2+} present in the 25.0 cm^3 sample of solution used.

[1]

(iii) Calculate the number of moles of $FeSO_4.xH_2O$ in 3.40 g of the compound.

[1]

(iv) Calculate the relative formula mass of $FeSO_4.xH_2O$.

[1]

(v) The relative formula mass of anhydrous iron(II) sulfate, $FeSO_4$, is 151.8.

Calculate the value of x in $FeSO_4.xH_2O$.

[1]

[Total: 9]

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2 Magnesium will react on heating with chlorine, or oxygen, or nitrogen to give the chloride, or oxide, or nitride respectively. Each of these compounds is ionic and in them magnesium has the same +2 oxidation state.

(c) Magnesium burns in nitrogen to give magnesium nitride, a yellow solid which has the formula Mg_3N_2.

Magnesium nitride reacts with water to give ammonia and magnesium hydroxide.

(i) Construct an equation for the reaction of magnesium nitride with water.

.....

(ii) Does a redox reaction occur when magnesium nitride reacts with water?

Use the oxidation numbers of nitrogen to explain your answer.

.....

.....

.....

.....

[4]

[Total: 11]

Mark Scheme ALvl Chem 6 EQ P2 22w to 09s Paper 2 Electrochemistry 35marks

Q# 134/ ALvl Chemistry/2021/w/TZ 1/Paper 4/Q# 3/www.SmashingScience.org

3(b)(i)	(+)5/V	1

Q# 135/ ALvl Chemistry/2021/w/TZ 1/Paper 4/Q# 1/www.SmashingScience.org

1(c)(iii)	**M1** S (increases) oxidation number –2 → 0 so oxidation / or is oxidised **M2** O (decreases) O.N. 0 → –2 so reduction / is reduced	2

Q# 136/ ALvl Chemistry/2020/s/TZ 1/Paper 4/Q# 2/www.SmashingScience.org

2(a)(i)	$2CuSO_4(aq) + 4KI(aq) \rightarrow 2CuI(s) + (1)I_2(aq) + 2K_2SO_4(aq)$ **M1** correct balancing **M2** correct state symbols	2
2(a)(ii)	Oxidation state of copper in $CuSO_4$ (+)2 AND Oxidation state of copper in CuI (+)1	1
2(a)(iii)	**M1** redox	1
	M2 iodide ions – lost electron(s) AND copper ions – gained electron(s)	1

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1(a)(ii)	It oxidises chlorine from –1 to 0	1

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1(a)(ii)	–1	1

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1(a)(i)	max O.N.	+1	(+)2	(+)3	(+)5	(+)6	+7	1

Q# 140/ ALvl Chemistry/2016/m/TZ 2/Paper 4/Q# 2/www.SmashingScience.org

2 (a) (i)	$\frac{27.30}{1000} \times 0.020 = \mathbf{5.46 \times 10^{-4}}$ (mol)	[1]	[1]
(ii)	(i) $\times 6 = \mathbf{3.28 \times 10^{-3}}$ (mol)	[1]	[1]
(iii)	(ii) $\times \frac{250}{25.00} = \mathbf{3.28 \times 10^{-2}}$ (mol)	[1]	[1]
(iv)	M_r of $FeCO_3$ = 55.8 + 12.0 + 3(16.0) = **115.8** (iii) $\times M_r(FeCO_3)$ = **3.79** g	[1] [1]	[2]
(v)	$\frac{\text{(iv)}}{5.00} \times 100\% =$ **75.9%**	[1]	[1]
(b) (i)	$2Fe^{3+} + Sn^{2+} \rightarrow 2Fe^{2+} + Sn^{4+}$ species balancing	[1] [1]	[2]
(ii)	$\mathbf{SnCl_2(aq)} + \mathbf{2}HgCl_2(aq) \rightarrow SnCl_4\mathbf{(aq)} + Hg_2Cl_2\mathbf{(s)}$ $SnCl_2$ AND 2 state symbols	[1] [1]	[2]
			[10]

Q# 141/ ALvl Chemistry/2014/w/TZ 1/Paper 4/Q# 1/www.SmashingScience.org

(c) (i)	(a species that) gains/takes electron(s)	1	[1]

Q# 142/ ALvl Chemistry/2014/s/TZ 1/Paper 4/Q# 2/www.SmashingScience.org

2 (a) (i)	(The MnO_4^- ions cause the Fe^{2+} ions to) lose electrons owtte/ora	1	1
(ii)	$MnO_4^-(aq) + 5Fe^{2+}(aq) + \mathbf{8}H^+(aq) \rightarrow \mathbf{Mn^{2+}}(aq) + 5Fe^{3+}(aq) + \mathbf{4}H_2O(l)$	1+1+1	3
(b) (i)	$\frac{20.0 \times 0.020}{1000} = 4(.00) \times 10^{-4}$ (mol)	1	1
(ii)	MnO_4^- : Fe^{2+} = 1 : 5 so amount of $Fe^{2+} = 5 \times 4.00 \times 10^{-4} = 2(.00) \times 10^{-3}$ (mol) ecf from **(b)(i)**	1	1
(iii)	$2.00 \times 10^{-3} \times 250/25 = 0.02(00)$ (mol) ecf from **(b)(ii)**	1	1
(iv)	3.40/0.02 = 170 ecf from **(b)(iii)**	1	1
(v)	170 – 151.8 = 18.2 18.2/18 = 1.01 x = 1 ecf from **(b)(iv)** if appropriate	1	1
			9

Q# 143/ ALvl Chemistry/2009/s/TZ 1/Paper 4/Q# 2/www.SmashingScience.org

(c) (i) $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$ (1)

(ii) Mg_3N_2 N is –3 (1)
NH_3 N is –3 (1)

No **because**
there is no change in the oxidation no. of N (1) [4]
e.c.f on **(c)(i)** and values of oxidation numbers

[Total: 11]