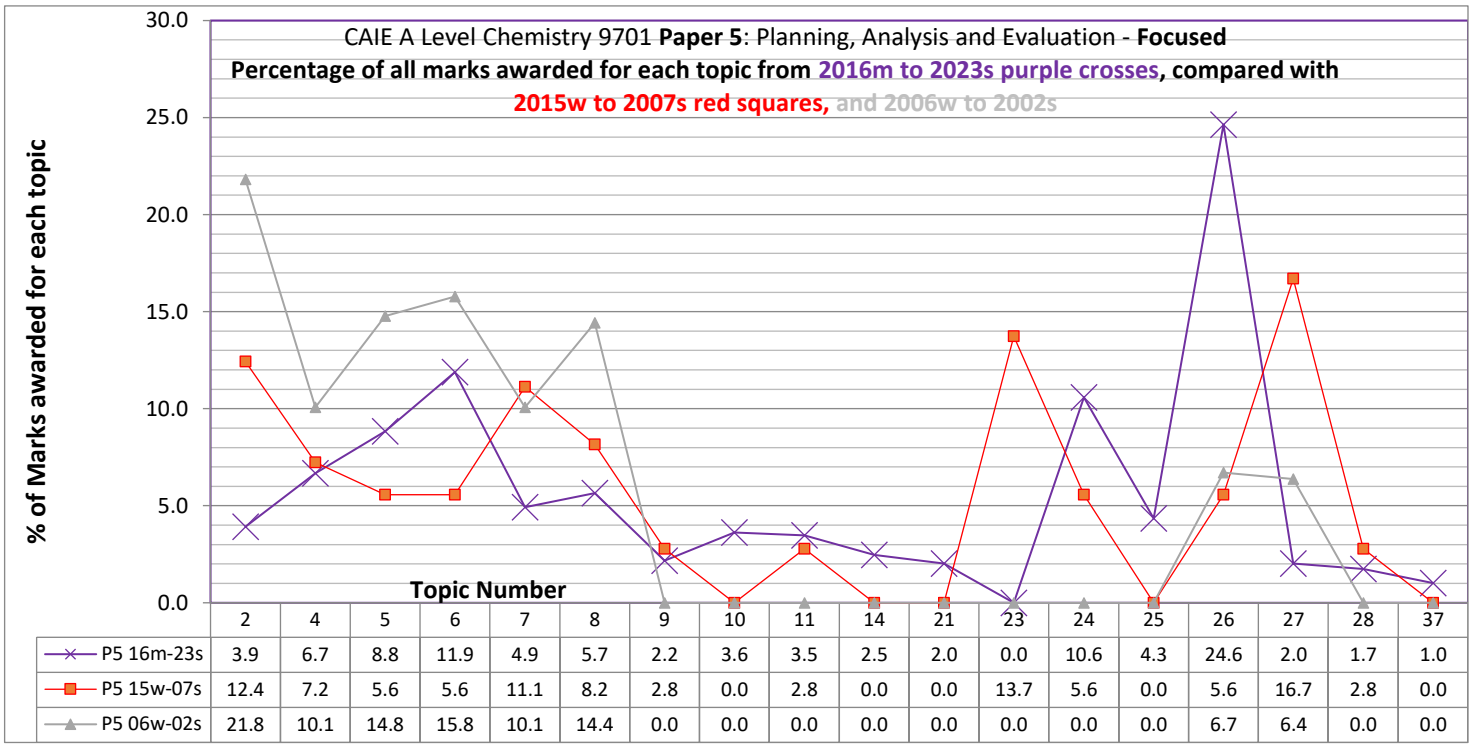
Name: Class: Date:

ALvl Chem 28 EQ P5 22w to 02s Paper 5 Chemistry of transition elements 27marks

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 3 minutes to complete.

Paper 5 Topic 28 Checklist Tick each task off as you go along	RANK: Marks	P5 Noob 1 Q Started	P5 Novice 1 Q done	P5 Bronze 10% of marks	P5 Silver 25% of marks	P4 Gold 40% of marks	P5[1] Winner 50% of marks	P5 Hero 75% of marks	P5 Legend 100% of marks
Topic (marks)	27		14	3	7	11	14	20	27
Time @150s/mark (minutes)	68		34	7	17	27	34	51	68



Topic Number	2	4	5	6	7	8	9	10	11	14	21	23	24	25	26	27	28	37
P5 16m-23s	3.9	6.7	8.8	11.9	4.9	5.7	2.2	3.6	3.5	2.5	2.0	0.0	10.6	4.3	24.6	2.0	1.7	1.0
P5 15w-07s	12.4	7.2	5.6	5.6	11.1	8.2	2.8	0.0	2.8	0.0	0.0	13.7	5.6	0.0	5.6	16.7	2.8	0.0
P5 06w-02s	21.8	10.1	14.8	15.8	10.1	14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	6.4	0.0	0.0

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 outcome from skillful action in study is being better at any important tasks even if circumstances are do not feel ideal.

Learning how to manage oneself so we can more reliably get ambitious and successful outcomes out of our challenges in a productive and positive way is one aspect of life's most valuable pursuit summarised and inscribed on the Temple of Apollo at Delphi: "know thyself".

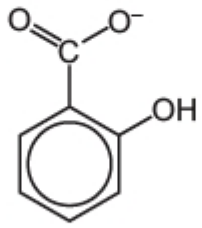
1. To complete these questions, as important as your answer, is checking your answer against the mark scheme.
2. For each question, or page, convert your mark score into a percentage. This will allow you to see (and feel) your progress as you get more experience and understanding with each topic.
3. If you find you get a higher percentage answering short answer questions than multiple choice questions that often means you are using the marking scheme correctly; your correct answer might not be fully complete. The marks easiest to miss rely on providing more details fully described.

[1] **DO NOT** work on these higher levels of completion unless you have also achieved at least a "**Gold**" (40%) in the same topic in **Paper 4**, which is **MOST** of your **A2 grade**.

2 Transition metal complex ions are coloured. The formula of a complex ion can be determined using colorimetry.

In colorimetry, light of a certain wavelength is passed through a complex ion solution. The absorbance of the light is proportional to the intensity of the colour of the solution. The more concentrated the complex ion solution, the more intense its colour and so the higher the absorbance.

A student carried out an experiment to determine the formula of the complex ion formed between aqueous iron(III) ions, $Fe^{3+}(aq)$, and aqueous 2-hydroxybenzoate ions, $C_6H_4(OH)CO_2^-$, which have the structure shown.



(a) In the first step of the experiment the student prepared 100.0 cm^3 of 0.0500 mol dm^{-3} aqueous iron(III) nitrate.

(i) Determine the mass, in g, of solid hydrated iron(III) nitrate, $Fe(NO_3)_3.9H_2O$, needed to prepare 100.0 cm^3 of a 0.0500 mol dm^{-3} solution.
[A_r: Fe, 55.8; N, 14.0; O, 16.0; H, 1.0]

mass of $Fe(NO_3)_3.9H_2O$ = ... g [2]

(ii) Describe how, after weighing the mass determined in **(i)**, the student should prepare 100.0 cm^3 of 0.0500 mol dm^{-3} aqueous iron(III) nitrate.

In your answer you must give the name and capacity, in cm^3, of any apparatus used.

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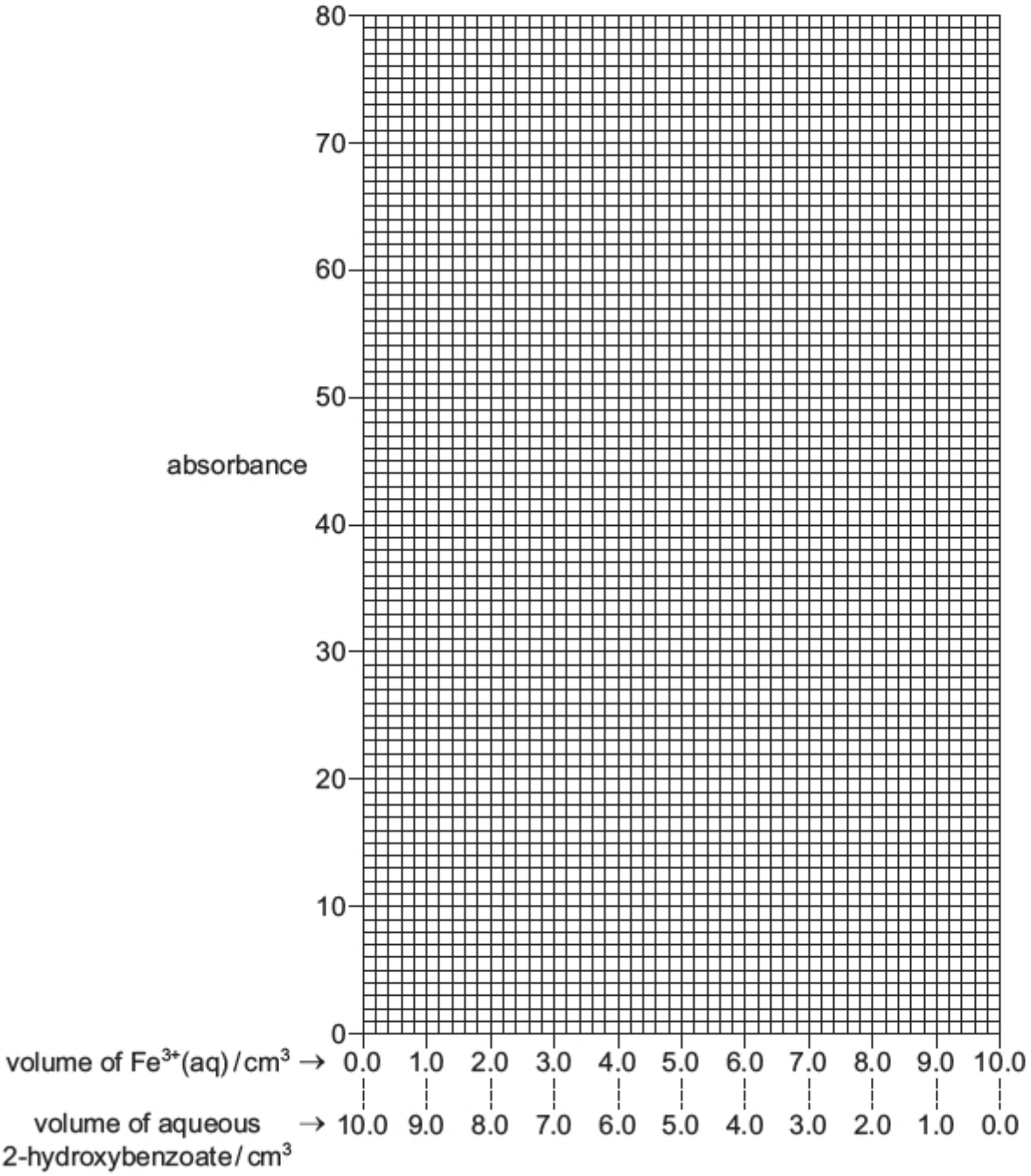
..... [2]

(b) The student prepared solutions containing various combinations of 0.0500 mol dm^{-3} $Fe^{3+}(aq)$ and 0.0500 mol dm^{-3} aqueous 2-hydroxybenzoate, as shown in the table.

The student placed a small sample of each solution into a colorimeter and measured the absorbance. The student made a mistake in test number **9** and did **not** measure the result.

test number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
volume of $Fe^{3+}(aq)$ / cm^3	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0		9.0	10.0
volume of aqueous 2-hydroxybenzoate / cm^3	10.0	9.0	8.0	7.0	6.0	5.0	4.0	3.0		1.0	0.0
absorbance	0	23	46	69	70	58	47	35		13	0

(i) Plot a graph on the grid to show the relationship between absorbance and the volumes of $Fe^{3+}(aq)$ and aqueous 2-hydroxybenzoate used.
Use a cross (×) to represent each data point. Draw **two** lines of best fit. [2]



(ii) Use the graph in **(i)** to determine the volumes of $Fe^{3+}(aq)$ and aqueous 2-hydroxybenzoate which would give the maximum absorbance.

volume of $Fe^{3+}(aq)$ = ... cm^3

volume of aqueous 2-hydroxybenzoate = ... cm^3 [1]

(iii) The point of maximum absorbance shows where all of the ions are combined in the complex.

Use the volumes in **(ii)** to determine the number of moles of 2-hydroxybenzoate ions that form a complex with 1 mole of Fe^{3+} ions.

moles of 2-hydroxybenzoate ions = ... [1]

(iv) $Fe^{3+}(aq)$ ions exist in aqueous solution as complex ions with the formula $[Fe(H_2O)_6]^{3+}(aq)$. 2-hydroxybenzoate ions, $C_6H_4(OH)CO_2^-$, are bidentate ligands.

Use this information and your answer to **(iii)** to suggest the formula of the complex ion formed between $Fe^{3+}(aq)$ ions and 2-hydroxybenzoate ions.

..... [1]

(v) Name the apparatus that should be used to measure the volumes of the solutions given in the table accurately.

..... [1]

(c) In test **9**, instead of mixing 8.0 cm^3 of $Fe^{3+}(aq)$ and 2.0 cm^3 of aqueous 2-hydroxybenzoate, the student mixed 16.0 cm^3 of $Fe^{3+}(aq)$ and 4.0 cm^3 of aqueous 2-hydroxybenzoate.

Use your graph in **(b)(i)** to suggest the absorbance that would have been measured if a sample of this solution had been analysed in the colorimeter.

absorbance = ... % [1]

(d) In a colorimetry experiment, the absorbance of the solution follows the relationship shown.

$$A = \varepsilon c l$$

A is the absorbance (no units).
c is the concentration in mol dm^{-3}.
l is the path length of the light travelling through the solution in cm.
ε is the molar absorption coefficient (a constant).

Determine the unit of ε.

unit = ... [1]

[Total: 12]

Q# 101/ ALvl Chemistry/2012/s/TZ 1/ Paper 5/Q# 1/www.SmashingScience.org :o)

1 When an excess of aqueous sodium hydroxide, NaOH, is added to 100 cm^3 of aqueous copper(II) sulfate, $CuSO_4$, a precipitate of copper(II) hydroxide, $Cu(OH)_2$, is produced.

The stoichiometric equation for this reaction is,

$$CuSO_4\,(aq) + 2NaOH\,(aq) \rightarrow Cu(OH)_2\,(s) + Na_2SO_4\,(aq)$$

The following information gives some of the hazards associated with these reactants.

Copper(II) sulfate (solid hydrated copper(II) sulfate $CuSO_4.5H_2O$)
Harmful. Dangerous for the environment.
Harmful if swallowed. Irritating to eyes and skin.
Solutions of concentrations equal to or greater than 1 mol dm^{-3} should be labelled HARMFUL.

Sodium hydroxide (solid NaOH)
Corrosive. Solutions of concentrations equal to or greater than 0.5 mol dm^{-3} are CORROSIVE.
Solutions of concentrations equal to or greater than 0.05 mol dm^{-3} but less than 0.5 mol dm^{-3} are IRRITANT.

You are to plan an experiment to investigate the molar ratio of the equation above and confirm that it remains unchanged as the concentration of the copper(II) sulfate changes.

(a) (i) Predict quantitatively how the number of moles of the precipitated copper(II) hydroxide varies as the molar concentration of the copper(II) sulfate increases until saturation is reached.

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(ii) Display your prediction in the form of a sketch graph. Remember that you are using 100 cm^3 of aqueous copper(II) sulfate. Label clearly the point representing the saturated solution of copper(II) sulfate. A saturated solution at 25° C has a concentration of 1.39 mol dm^{-3}. Give appropriate numerical scales to the two axes.

[3]

(b) In the experiment you are about to plan, identify the following.

(i) the independent variable .....

(ii) the dependent variable .....

(iii) one other variable to be controlled .....[2]

(c) Design a laboratory experiment to investigate your prediction in **(a)**.

In addition to the standard apparatus present in a laboratory you are provided with the following materials.

aqueous sodium hydroxide, NaOH (2.0 mol dm^{-3})
solid hydrated copper(II) sulfate, $CuSO_4.5H_2O$

Give a step-by-step description of how you would

(i) prepare enough solutions of copper(II) sulfate of an appropriate range of concentrations to give sufficient data to plot a graph as in **(a)(ii)**,

(ii) collect and dry the precipitated copper(II) hydroxide,

(iii) calculate the molar concentration of one of the solutions of copper(II) sulfate.
[A_r: H, 1.0; O, 16.0; S, 32.1; Cu, 63.5]

[5]

(d) (i) State two hazards that must be considered when planning the experiment.

.....

.....

.....

(ii) State a precaution that should be taken to minimise the risk of one of these hazards.

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.....[3]

(e) Draw up a table with appropriate headings to show the data you would record when carrying out your experiments and the values you would calculate in order to construct a graph to support or reject your prediction in (a). The headings should include the appropriate units.

[2]

Mark Scheme ALvl Chem 28 EQ P5 22w to 02s Paper 5 Chemistry of transition elements 27marks

Q# 100/ ALvl Chemistry/2017/m/TZ 2/ Paper 5/Q# 2/www.SmashingScience.org :o)

2(a)(i)	**M1** mol of $Fe(NO_3)_3.9H_2O$ needed = 0.05 × 100/1000 = 0.005(00) mol	1
	M2 0.0005 × 403.8 = 2.02 g	1
2(a)(ii)	**M1** *dissolving of solid / making of a solution* dissolve (2.02 g / answer to **2(a)(i)** of) hydrated salt in (a container with) distilled water / less than 100 cm^3 of water	1
	M2 *making it into a standard solution* (transfer / add to) a (100 cm^3) volumetric flask; make to mark(with (distilled) water) (and shake)	1
2(b)(i)	**M1** all points plotted	1
	M2 two lines which are extrapolated to meet	1
2(b)(ii)	correct reading of volume of Fe^{3+} **and** volume of 2-hydroxybenzoate ions from graph combined to make 10.0 cm^3 (expected values: Fe^{3+} = 3.3 cm^3; 2-hydroxybenzoate = 6.7 cm^3)	1
2(b)(iii)	2	1
2(b)(iv)	$[Fe(H_2O)_2(HO–C_6H_4–CO_2)_2]^+$	1
2(b)(v)	burette(s)	1
2(c)	23±1%	1
2(d)	$dm^3\,cm^{-1}\,mol^{-1}$	1

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1 (a) (i)	PLAN Problem	States that the moles of copper(II) hydroxide increase as the molar concentration of copper(II) sulfate increases and sketches a line from the origin with an initial positive gradient. Ignore any subsequent plateau or maximum on this line.	[1]
(ii)		A straight line terminating at the point of saturation with marked co-ordinates: award 2 marks.	[1]
		A straight line clearly terminating within the grid but without marked co-ordinates: award 1 mark.	[1]
		A line (not necessarily straight) which does not terminate at the saturation point but with the co-ordinates marked: award 1 mark. This line can plateau after the saturation point.	

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		A line (not necessarily straight) which does not terminate at the saturation point but with the co-ordinates marked: award 1 mark. This line can plateau after the saturation point.	
(b)	PLAN Problem	**(i)** concentration of copper(II) sulfate.	[1]
		(ii) moles of copper(II) hydroxide	[1]
(c)	PLAN Method	Indicates at least five experiments. These may be shown in the table in **1(e).** Five blank rows in the table are acceptable.	[1]
		A range of concentrations over at least 0.8 mol dm^{-3}, which must cover 1.0 mol dm^{-3}, up to a maximum of 1.39. Accept a range of mass of copper(II) sulfate (with solution volume) that has been calculated satisfying the same concentration criteria.	[1]
		Filtering/centrifuging	[1]
		Method of drying and weighing the precipitate. Include washing with water (and propanone), (air) drying and weighing (to constant mass). Do not accept direct heating, blotting or a statement that the precipitate is simply left to dry.	[1]
		A suitable calculation of a molarity, even if greater than 1.39 (M_r of the copper(II) sulfate must be used). Check that the solution is made up to the appropriate volume and not that a mass is added to a fixed volume of water.	[1]
(d)	PLAN Method	Identifies that copper(II) sulfate is harmful/a danger to the environment.	[1]
		Identifies that sodium hydroxide is corrosive (from the hazcard information).	[1]
		Give one mark for a precaution for either hazard of (chemical) resistant gloves or large dilution when disposing of chemicals.	[1]
(e)	PLAN Method	This table must match the plan in **1(c).** Five or four columns are required depending on whether serial dilution is used to prepare the solutions: Either **(i)** mass of copper(II) sulfate/g or **(ii)** volume of copper sulfate solution/cm^3 and volume of water/cm^3 for serial dilutions; mass/weight of copper(II) hydroxide/g; concentration of copper(II) sulfate/mol.dm^{-3}; number of moles of copper(II) hydroxide (no unit). The full word for the unit can be used with or without / or (). Ignore other column headings and units. If Five or Four are fully correct, two marks; four or three correct, one mark; otherwise zero.	[2]