TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAM

CANDIDATE NAME	
CIVICS GROUP	

H2 CHEMISTRY **9729**

Paper 4 Practical

31 August 2021

2 hours 30 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name and Civics Group in the spaces at the top of the page.

Give details of the practical shift and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the question paper.

The use of an approved calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Qualitative Analysis Notes are printed on pages 19 and 20.

The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	/18
2	/16
3	/14
4	/7
Total	**/ 55**

This document consists of **19** printed pages and **1** blank page.

Answer **all** the questions in the space provided.

1 Determination of the percentage by mass of iron(II) sulfate in an iron tablet

Iron tablets are used for the treatment of iron deficiency. The active ingredient in these iron tablets is commonly iron (II) sulfate and all the iron is present as Fe^{2+} cations. The percentage of iron in the tablet can be determined by titrating a solution of this salt with a standard solution of aqueous potassium manganate(VII) solution, $KMnO_4$.

The reaction between aqueous manganate(VII) ions and iron(II) ions is as follows:

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

FA 1 contains 3 iron tablets which have been crushed to a powder.
FA 2 is 0.00500 mol dm^{-3} potassium manganate(VII), $KMnO_4$
FA 3 is 1.00 mol dm^{-3} sulfuric acid, H_2SO_4.

In this experiment, you will determine the percentage of iron(II) sulfate heptahydrate, $FeSO_4.7H_2O$ present in the iron tablets in **FA 1**.

(a) (i) Preparation of FA 4, a solution of FA 1

1. Use a measuring cylinder to transfer 100 cm^3 of **FA 3** into a conical flask.
2. Weigh the capped container of **FA 1**. Record the mass in the space below.
3. Tip all the **FA 1** into the conical flask.
4. Reweigh the container with its cap and record its mass.
5. Calculate and record the mass of **FA 1** used.

mass of **FA 1** used = ……………. g

6. **Warm** the mixture in the conical flask gently, **do not overheat**, and stir for about two minutes.
7. Allow the flask to cool for about five minutes.
8. Filter the mixture into a 250 cm^3 volumetric flask. Ensure that no solution is lost. It should be noted that the filtration takes time. **Proceed to Question 2 or 3 whilst the mixture is filtering.**
9. Wash out the conical flask with deionised water and add the washings through the filter into the volumetric flask.
10. Make up the contents of the flask to the 250 cm^3 mark with deionised water. Stopper and mix the contents thoroughly by inverting the flask a number of times.
11. Label this solution **FA 4**.

(ii) Titration of FA 4 with FA 2

1. Fill the burette with **FA 2**.
2. Pipette 25.0 cm^3 of **FA 4** into a conical flask.
3. Use the measuring cylinder to add 25 cm^3 of **FA 3** to the conical flask.
4. Titrate **FA 4** with **FA 2** until the appearance of the first permanent pale-pink colour.
5. Carry out as many accurate titrations as you think necessary to obtain consistent results.
6. Record your titration results in the space below. Make certain that the recorded results show the precision of your practical work.

[5]

(b) From your titrations, obtain a suitable volume of **FA 2** to be used in your calculations. Show clearly how you obtained this volume.

25.0 cm^3 of **FA 4** required ………………cm^3 of **FA 2** [1]

(c) Calculations

(i) Calculate the amount of potassium manganate(VII) present in the volume of **FA 2** calculated in **(b).**

amount of $KMnO_4$ = …………………….. mol [1]

(ii) Calculate the amount of Fe^{2+}(aq) present in 25.0 cm^3 of **FA 4** in the conical flask.

amount of Fe^{2+}(aq) in the conical flask = …………………….. mol [1]

(iii) Calculate the amount of Fe^{2+} in the given sample of **FA 1**.

amount of Fe^{2+}(aq) in **FA 1** = …………………….. mol [1]

(iv) Hence calculate the percentage by mass of $FeSO_4.7H_2O$ in **each** iron tablet.
You may assume that the tablets have identical composition.

[A_r: H, 1.0; O, 16.0; S, 32.1; Fe, 55.8]

percentage by mass of $FeSO_4.7H_2O$ in one iron tablet =.......................... [3]

(d) **(i)** Suggest why the crushed tablets were dissolved in H_2SO_4 (**FA 3**) rather than in water.

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.... [1]

(ii) A student decided to repeat the experiment but used HC*l* to acidify $KMnO_4$ instead of H_2SO_4 (in **FA 3**). Suggest how this would affect the titre value. Explain your answer.

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.... [1]

(iii) The uncertainty associated with each reading using a 25.0 cm^3 pipette and a burette are ±0.06 cm^3 and ±0.05 cm^3 respectively.

A student suggested that it would have been more accurate to measure the volume of **FA 4** using a burette instead of the pipette.

State and explain whether you agree with the student.

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.... [1]

[Turn over

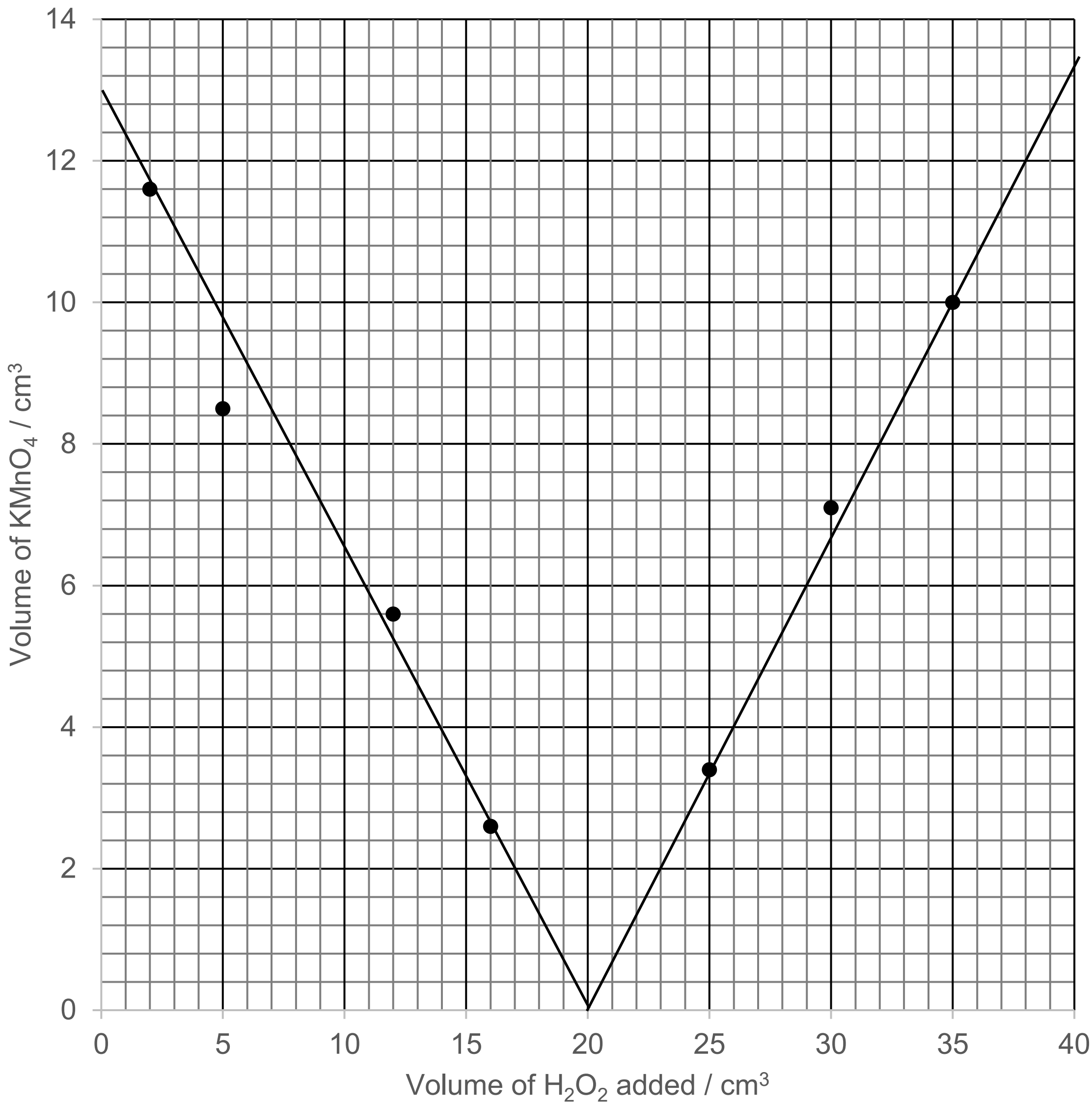
(e) Another student conducted the following experiment to determine the concentration of hydrogen peroxide (H_2O_2) by using the reaction between Fe^{2+}(aq) and MnO_4^-(aq) ions.

Different volumes of H_2O_2 were added to separate 25.0 cm^3 samples of 0.0400 mol dm^{-3} Fe^{2+}(aq) solution. Fe^{2+}(aq) is oxidised by hydrogen peroxide as shown by the following equation.

$$2Fe^{2+} + H_2O_2 + 2H^+ \rightarrow 2Fe^{3+} + 2H_2O$$

The remaining Fe^{2+}(aq) ions in each of the resulting mixtures were then titrated against $KMnO_4$ under acidic conditions. Fig. 1.1. shows the graph of volume of $KMnO_4$ against volume of H_2O_2.

Fig. 1.1



(i) By considering the information given in part **(e)**, mark on the graph in Fig. 1.1, a point **X,** from which you can obtain information to determine the concentration of hydrogen peroxide in mol dm^{-3} in this experiment.

[1]

(ii) Circle and label on the graph any point(s) you consider to be anomalous.

[1]

(iii) Comment on whether the results of the experiment shown in Fig 1.1 can be considered to be reliable.

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[1]

[Total: 18]

[Turn over

2 Qualitative analysis of some inorganic reactions

FA 5 is a salt consisting of two ions, both of which can be found in the Qualitative Analysis Notes on pages 19 and 20.

FA 6 is a sample of the residue obtained from **FA 5** after strong heating.

Unless otherwise stated, the volumes given below are approximate and should be estimated rather than measured. Details of colour changes should be noted and you should indicate clearly at what stage in a test a change occurs.

Test and identify any gases evolved.

(a) Analysis involving FA 5

(i) Place a small spatula measure of **FA 5** into a boiling-tube. Heat the boiling tube gently at first, and then more strongly. Record **all** your observations.

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.... [3]

(ii) When **FA 5** is heated strongly for an extended period of time, it forms a residue. A sample of this residue, **FA 6**, is provided for your use.

Place a small spatula measure of **FA 6** in a test-tube and add a 1 cm depth of aqueous hydrogen peroxide. Record your observations.

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.... [1]

(iii) Dissolve a spatula measure of **FA 5** in a 3 cm depth of distilled water in a boiling tube. This solution is **FA 5(aq)**. Perform the tests in Table 2.1 using this **FA 5(aq)** and record your observations.

Keep the remainder of FA 5(aq) for use in 2(b)(ii).

Table 2.1

	test	observations
1.	Put about a 1 cm depth of **FA 5(aq)** into a test-tube. Add aqueous sodium hydroxide dropwise, with shaking, until no further change is seen.	
2.	Put about a 1 cm depth of **FA 5(aq)** to a test-tube. Add a 1 cm depth of aqueous hydrogen peroxide, then	
	add aqueous sodium hydroxide	

[3]

FA 7 is a solution of a different salt. The cation present in **FA 7** is **not** listed in the Qualitative Analysis Notes on page 19.

(b) Analysis involving FA 5(aq) and FA 7

(i) **FA 5(aq)** and **FA 7** each contain a halide ion or an anion containing sulfur. These anions are listed in the Qualitative Analysis Notes on page 20.

For both of these anions, select reagents that you would use in order to carry out tests that give positive results.

Record the reagents you have selected in Table 2.2.

Table 2.2

test	ion tested	reagents
1	halide	
2	sulfur-containing anion	

[2]

(ii) Carry out both of your tests on **FA 5(aq)** and **FA 7** and record your results Table 2.3.
You should indicate clearly at which stage a change occurs.
If there is no observable change, write **no observable change**.

Table 2.3

test	observations	
	FA 5(aq)	**FA 7**
1		
2		

[3]

(iii) Use your observations in **(a)** and **(b)(ii)** to identify the ions present in **FA 5** and **FA 7**. Write the formula of each ion in Table 2.4. If the tests you carry out do not allow you to identify any of the ions, write 'unknown'.

Table 2.4

	FA 5	**FA 7**
cation		
anion		

[2]

(iv) Suggest what you would observe if you added aqueous chlorine to separate portions of aqueous solutions of **FA 5** and **FA 7**.

Do not carry out these tests.

aqueous chlorine and **FA 5(aq)**

……………………………………………………………………………………………………

aqueous chlorine and **FA 7(aq)**

……………………………………………………………………………………………………

[2]

[Total: 16]

[Turn over

3 Determination of the concentration of an alkali and the enthalpy change of neutralisation

In this experiment, you will determine the concentration of an alkali. You will mix different volumes of acid with a fixed volume of alkali and measure the temperature rise that occurs each time. You will then determine the enthalpy change for the neutralisation of the acid with the alkali.

FA 8 is aqueous sodium hydroxide, NaOH.
FA 9 is 1.50 mol dm^{-3} sulfuric acid, H_2SO_4.

NOTE: You should minimise contact with FA 8 and FA 9.

(a) Method

1. Use the thermometer to measure and record the initial temperature of **FA 8**.
Wash and dry the thermometer after this use.

initial temperature of **FA 8** = ………………. °C

2. Support a Styrofoam cup in a 250 cm^3 beaker.

Experiment 1

3. Use the 10 cm^3 pipette to transfer 10.0 cm^3 of **FA 8** into the Styrofoam cup.
4. Using a 10 cm^3 measuring cylinder, add 8.0 cm^3 of distilled water into the Styrofoam cup.
5. Use another 10 cm^3 measuring cylinder to add 2.0 cm^3 of **FA 9** into the Styrofoam cup.

Stir the mixture and measure the maximum temperature reached. (You may need to tilt the cup so that the bulb of the thermometer is completely immersed.) Record the maximum temperature.
6. Empty, rinse and shake dry the plastic cup, ready for use in the next experiment.

Experiments 2 to 5

7. Repeat the procedure in steps 3 – 6 to carry out **experiments 2 to 5**, using the volumes of **FA 8**, water and **FA 9** shown in the Table 3.1. Record the maximum temperature reached in each experiment.

Table 3.1

experiment	volume of **FA 8** / cm^3	volume of H_2O / cm^3	volume of **FA 9** / cm^3	maximum temperature / °C
1	10.0	8.0	2.0	
2	10.0	6.0	4.0	
3	10.0	4.0	6.0	
4	10.0	3.0	7.0	
5	10.0	0.0	10.0	
6	10.0			

8. Carry out **one** further experiment which will enable you to determine more precisely the minimum volume of **FA 9** that gives the highest maximum temperature. This is **Experiment 6**.
   Record the volumes of water and **FA 9** and the maximum temperature in Table 3.1.

[3]

(b) On the grid below, plot a graph of maximum temperature reached on the *y*-axis and volume of **FA 9** on the *x*-axis.

Select a scale on the *y*-axis which includes a temperature 3.0 °C above the maximum temperature reached.

Draw two **straight** lines of best fit on your graph. The first line is for increasing maximum temperature and the second after the maximum temperature was reached.

Extrapolate the two lines so that they intersect.

[Turn over

Use your graph to determine the volume of **FA 9** that reacts with 10.0 cm^3 of **FA 8** and the maximum temperature reached for the reaction.

volume of **FA 9** = ……………… cm^3

maximum temperature = ……………….. °C

[4]

(c) **(i)** Calculate the energy evolved when the volume of **FA 9** in **(b)** is neutralised by **FA 8**, sodium hydroxide.
Assume that 4.18 J of energy changes the temperature of 1.0 cm^3 of solution by 1.0 °C.

energy evolved = ………………….. [1]

(ii) Calculate the amount of sulfuric acid in the volume of **FA 9** in **(b)**.

amount of H_2SO_4 = ………………….. [1]

(iii) Calculate the enthalpy change of the reaction, ΔH_r.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) \qquad \Delta H_r$$

ΔH_r = ……..……………… [1]

(iv) Use your answer to **(c)(ii)** to calculate the concentration, in mol dm^{-3}, of NaOH in **FA 8.**

concentration of NaOH in **FA 8** = …………………………… [2]

(d) Apart from using more precise apparatus to measure volumes and temperature, better insulation or taking more readings, suggest **one** modification to the **procedure** which would make the value for the enthalpy change of neutralisation calculated in **(c)(iii)** more accurate.

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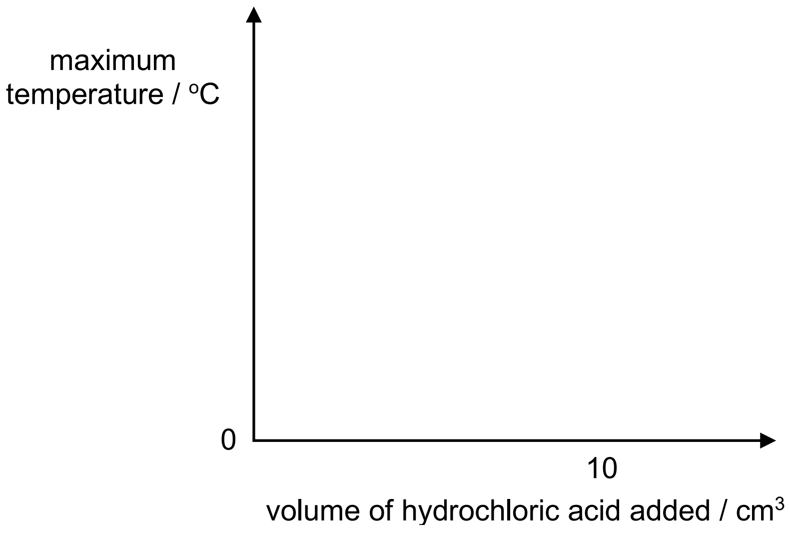
…………………………………………………………………………………………………… [1]

(e) In another series of experiments, a student carried out **experiments 1 to 5** following the procedure described above using 1.5 mol dm^{-3} sodium hydroxide and 1.0 mol dm^{-3} hydrochloric acid.
Sketch, on the axes provided below, the graph that might be obtained if the maximum temperature reached was plotted against volume of acid.



[1]

[Total: 14]

[Turn over

4 Planning

When magnesium and hydrochloric acid react, a vigorous effervescence of hydrogen gas is observed.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

When a small clean piece of magnesium ribbon was dropped into a small beaker containing 2.00 mol dm^{-3} hydrochloric acid, it was observed that the magnesium dissolved after a short while.

The order of reaction with respect to hydrochloric acid is thought be either one or zero.

(a) By considering the description given above, write a plan for a series of experiments which can be carried out to determine the order of reaction with respect to hydrochloric acid.

In your plan, you should carry out a series of five experiments in which the concentration of hydrochloric acid is varied.

You may assume that you are provided with the following:

- long strip of clean magnesium ribbon of mass about 2.0 g
- 500 cm^3 of 2.00 mol dm^{-3} hydrochloric acid
- deionised water
- the apparatus normally found in a school or college laboratory

Your plan should contain details of the following:

- how you would determine the quantities you would use, so that there is an excess of hydrochloric acid in each experiment;
- the apparatus you would use, including capacities where relevant;
- the procedure you would follow and the measurements you would make;
- how you would use the results to plot a suitable graph which can be used to determine the order of reaction with respect to hydrochloric acid.

[A_r: H, 1.0; Mg, 24.3; Cl, 35.5]

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[6]

(b) Suggest why the proposed method of determining the reaction time in **(a)** may lead to inaccuracies in the readings recorded.

[1]

[Total: 7]

[Turn over

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Qualitative Analysis Notes
[ppt. = precipitate]

(a) Reactions of aqueous cations

cation	***reaction with***	
	$NaOH$(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+ (aq)	ammonia produced on heating	–
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white. ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt., turning brown on contact with air insoluble in excess	green ppt., turning brown on contact with air insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt., rapidly turning brown on contact with air insoluble in excess	off-white ppt., rapidly turning brown on contact with air insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

[Turn over

(b) Reactions of anions

anion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $Cl^-(aq)$	gives white ppt. with $Ag^+(aq)$ (soluble in $NH_3(aq)$)
bromide, $Br^-(aq)$	gives pale cream ppt. with $Ag^+(aq)$ (partially soluble in $NH_3(aq)$)
iodide, $I^-(aq)$	gives yellow ppt. with $Ag^+(aq)$ (insoluble in $NH_3(aq)$)
nitrate, NO_3^- (aq)	NH_3 liberated on heating with $OH^-(aq)$ and Al foil
nitrite, NO_2^- (aq)	NH_3 liberated on heating with $OH^-(aq)$ and Al foil; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
sulfate, SO_4^{2-} (aq)	gives white ppt. with $Ba^{2+}(aq)$ (insoluble in excess dilute strong acids)
sulfite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with $Ba^{2+}(aq)$ (soluble in excess dilute strong acids)

(c) Tests for gases

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	"pops" with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns aqueous acidified potassium manganate(VII) from purple to colourless

(d) Colour of halogens

halogen	*colour of element*	*colour in aqueous solution*	*colour in hexane*
chlorine, Cl_2	greenish yellow gas	pale yellow	pale yellow
bromine, Br_2	reddish brown gas / liquid	orange	orange-red
iodine, I_2	black solid / purple gas	brown	purple