



Stage 6

Module 8: Applying Chemical Ideas

Inorganic Substances

Teacher: Samantha Wong

Exam Equivalent Time: 223.5 minutes (based on allocation of 1.5 minutes per mark)



Questions

1. CHEMISTRY, M8 2018 HSC 4 MC

Which of the following greatly enhanced scientific understanding of the effects of trace elements?

- A. Improved filtration techniques
- B. The development of atomic absorption spectroscopy
- C. The creation of new elements in particle accelerators
- D. The work of Le Chatelier in describing chemical equilibrium

2. CHEMISTRY, M8 2013 VCE 8* MC

A forensic chemist tests mud from a crime scene to determine whether the mud contains zinc. Which one of the following analytical techniques would be best suited to this task?

- A. infrared spectroscopy
B. mass spectroscopy
C. atomic absorption spectroscopy
D. nuclear magnetic resonance spectroscopy

3. CHEMISTRY, M8 2015 HSC 3 MC

What flame colour do copper ions produce when heated?

- A. Brick red
B. Blue-green
C. Pale purple
D. Yellow-orange

4. CHEMISTRY, M8 2017 HSC 2 MC

Which row of the table correctly matches an ion with its flame colour during a flame test?

	<i>Ion</i>	<i>Flame colour</i>
A.	Barium	Orange-red
B.	Calcium	Blue-green
C.	Carbonate	Orange-red
D.	Copper	Blue-green

5. CHEMISTRY, M8 2022 HSC 5 MC

Which pair of ions can be distinguished using a flame test in the school laboratory?

- A. Ag^+ and Mg^{2+}
B. Ba^{2+} and Ca^{2+}
C. Br^- and Cl^-
D. Fe^{2+} and Fe^{3+}

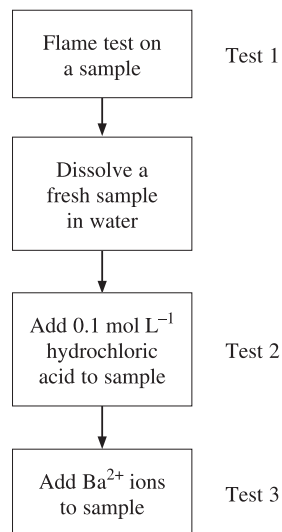
6. CHEMISTRY, M8 2024 HSC 8 MC

Which pair of ions produce different colours in a flame test?

- A. Br^- and Cl^-
B. Ag^+ and OH^-
C. Cu^{2+} and Ca^{2+}
D. CH_3O^- and H_2PO_4^-

7. CHEMISTRY, M8 2016 HSC 13 MC

The flow chart shows the steps used to identify a sample of a substance.



If the substance is sodium sulfate, what should have been observed in Tests 1,2 and 3 ?

	Test 1	Test 2	Test 3
A.	Bright orange flame	No bubbles	White precipitate formed
B.	Bright orange flame	Bubbles	No precipitate formed
C.	Blue-green flame	No bubbles	No precipitate formed
D.	Blue-green flame	Bubbles	White precipitate formed

8. CHEMISTRY, M8 2016 HSC 19 MC

Excess barium nitrate solution is added to 200 mL of 0.200 mol L⁻¹ sodium sulfate.

What is the mass of the solid formed?

- A. 4.65 g
- B. 8.69 g
- C. 9.33 g
- D. 31.5 g

9. CHEMISTRY, M8 2017 HSC 19 MC

The sulfate content of a fertiliser is 48% by mass. 1.20 g of this fertiliser is completely dissolved in water and an excess of Ba(NO₃)₂ (aq) is added.

What mass of precipitate would be formed?

- A. 0.006 g
- B. 0.58 g
- C. 1.40 g
- D. 1.57 g

10. CHEMISTRY, M8 2021 HSC 2 MC

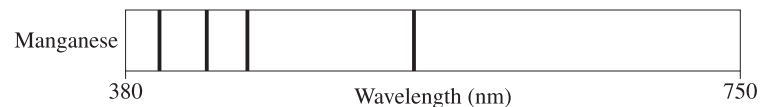
Which ion can be detected using a precipitation reaction with silver nitrate?

- A. Ag⁺
- B. Cl⁻
- C. Mg²⁺
- D. NO₃⁻

11. CHEMISTRY, M8 2022 HSC 4 MC

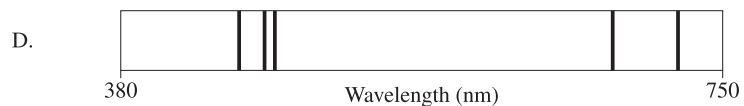
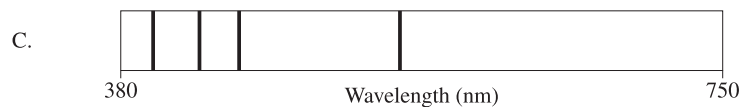
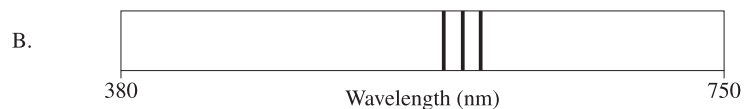
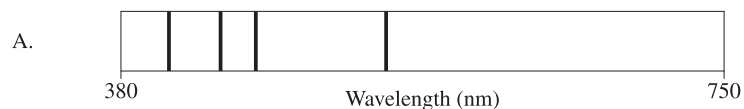
An analytical chemist was using atomic absorption spectroscopy (AAS) to determine the manganese concentration in a sample.

The following diagram shows the absorbance lines of manganese.



The diagrams below show the emission spectra of four AAS lamps.

Which lamp should be used to determine the manganese concentration in the sample?



12. CHEMISTRY, M8 2023 HSC 13 MC

The table shows four separate tests used to identify a dilute, aqueous sample of a compound.

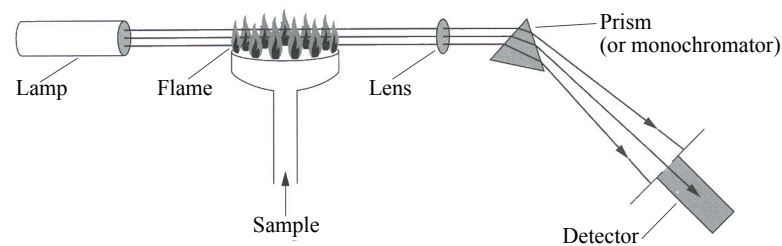
Test Number	Test	Observation
1	Test with Red litmus	Stays red
2	Add Ba^{2+} ions to a sample	White precipitate formed
3	Add OH^- ions to a sample	Brown precipitate formed
4	Add Cl^- ions to a sample	White precipitate formed

Which compound would produce the observations shown?

- A. Silver sulfate
- B. Lead(II) acetate
- C. Iron(II) bromide
- D. Magnesium carbonate

13. CHEMISTRY, M8 2023 HSC 2 MC

The technique illustrated is used to analyse chemical substances in a sample.



What is the technique shown?

- A. Flame test
- B. Mass spectrometry
- C. Atomic absorption spectroscopy
- D. Ultraviolet-visible spectrophotometry

14. CHEMISTRY, M8 2015 HSC 18-19 MC

A sample of pond water from a contaminated site was analysed to determine the concentration of lead ions using the following procedure.

- A measuring cylinder was used to collect a 50 mL sample from the pond.
- The sample was placed in a clean dry beaker.
- 25.0 mL of 0.200 mol L^{-1} sodium chloride solution was added to the sample.
- The precipitate of lead(II) chloride that formed was filtered, dried and weighed. It had a mass of 0.13 g.

Question 18

How could the reliability of the analysis of the pond water be improved?

- A. Analyse more samples from the same pond
- B. Use 50 mL of distilled water as a control sample
- C. Analyse samples from different ponds on the site
- D. Remove other contaminants from the sample before the analysis

Question 19

What was the concentration of lead ions in the sample?

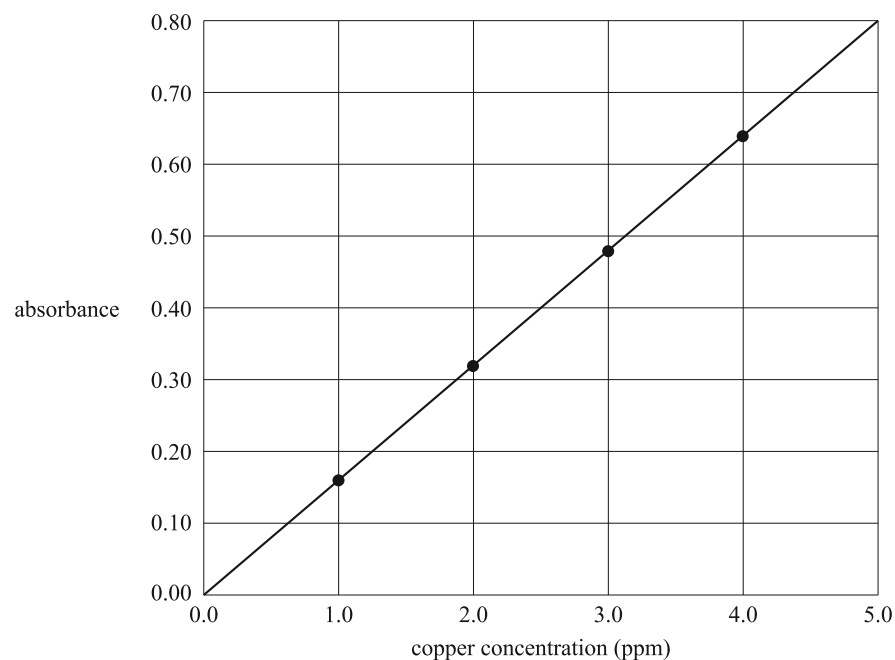
- A. $5.0 \times 10^{-3} \text{ mol L}^{-1}$
- B. $5.8 \times 10^{-3} \text{ mol L}^{-1}$
- C. $9.3 \times 10^{-3} \text{ mol L}^{-1}$
- D. $10.7 \times 10^{-3} \text{ mol L}^{-1}$

15. CHEMISTRY, M8 2014 VCE 16-17 MC

An atomic absorption spectrometer can be used to determine the level of copper in soils. The calibration curve below plots the absorbance of four standard copper solutions against the concentration of copper ions in ppm.

The concentrations of copper ions in the standard solutions were 1.0, 2.0, 3.0 and 4.0 mg L^{-1} . ($1 \text{ mg L}^{-1} = 1 \text{ ppm}$)

Copper calibration curve



Question 16

The concentration of copper in a test solution can be determined most accurately from the calibration curve if it is between

- A. 0.0 ppm and 5.0 ppm.
- B. 0.0 ppm and 4.0 ppm.
- C. 1.0 ppm and 4.0 ppm.
- D. 1.0 ppm and 5.0 ppm.

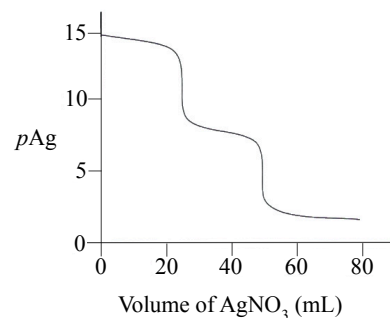
Question 17

If the test solution gave an absorbance reading of 0.40, what would be the concentration of copper ions in the solution in mol L^{-1} ?

- A. 2.5
 - B. 3.9×10^{-2}
 - C. 3.9×10^{-5}
 - D. 2.5×10^{-6}
-

16. CHEMISTRY, M5 2023 HSC 16 MC

A solution contains potassium iodide and potassium chloride. It was analysed by performing a precipitation titration using silver nitrate. The titration curve for this reaction is shown, where $p\text{Ag} = -\log_{10} [\text{Ag}^+]$.



Why is this a valid and correct procedure for quantifying the amount of each anion present in the mixture?

- A. AgCl would precipitate out first, followed by AgI.
 - B. AgI would precipitate out first, followed by AgCl.
 - C. Both AgI and AgCl precipitate out of the solution together.
 - D. Neither AgCl nor AgI would precipitate out of the solution.
-

17. CHEMISTRY, M8 2022 HSC 16 MC

A blue solution of copper(II) sulfate was investigated using colourimetry. Orange light ($\lambda = 630$ nm) was used and the pathlength was 1.00 cm.

Which change would result in a higher absorbance value?

- A. Diluting the solution
 - B. Using a higher intensity lamp
 - C. Using blue light ($\lambda = 450$ nm)
 - D. Setting the pathlength to 2.00 cm
-

18. CHEMISTRY, M8 2017 HSC 8 MC

There are two unlabelled solutions. One is barium nitrate and the other lead nitrate.

Which of the following could be added to the two unlabelled solutions to distinguish between them?

- A. Sodium sulfate
 - B. Sodium nitrate
 - C. Sodium chloride
 - D. Sodium carbonate
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19. CHEMISTRY, M8 2018 HSC 16 MC

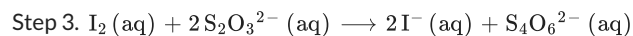
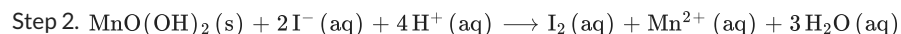
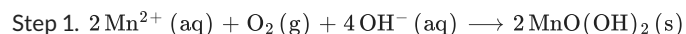
An investigation was carried out to determine the calcium ion concentration of a 2.0 L sample of tap water. Excess Na_2CO_3 was added to the sample. The precipitate was filtered, dried and weighed. The mass of the dried precipitate was 400 mg.

What was the concentration of calcium ions in the sample of tap water?

- A. 80 mg L^{-1}
 - B. 160 mg L^{-1}
 - C. 200 mg L^{-1}
 - D. 400 mg L^{-1}
-

20. CHEMISTRY, M8 2018 HSC 20 MC

The Winkler method is used to determine the amount of dissolved oxygen in a water sample. The procedure involves the following sequence of reactions.



When a 5.00 L sample of water was analysed using the Winkler method, a total of 4.00×10^{-3} mol of thiosulfate $\text{S}_2\text{O}_3^{2-}$ was required in Step 3.

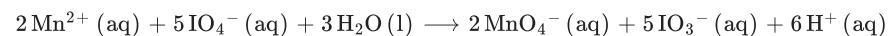
What concentration of oxygen was present in the original sample?

- A. 3.20 mg L⁻¹
 - B. 6.40 mg L⁻¹
 - C. 12.8 mg L⁻¹
 - D. 32.0 mg L⁻¹
-

21. CHEMISTRY, M8 2019 HSC 20 MC

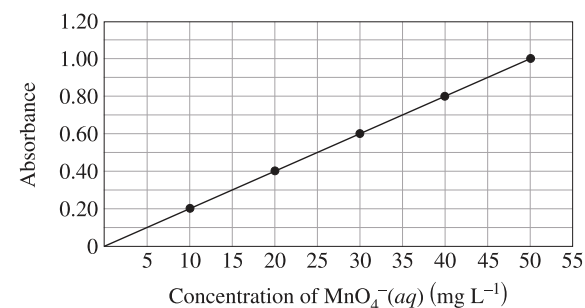
The manganese content in a 12.0 gram sample of steel was determined by measuring the absorbance of permanganate (MnO_4^{-}) using the following process.

The steel sample was dissolved in nitric acid and the $\text{Mn}^{2+}(\text{aq})$ ions produced were oxidised to $\text{MnO}_4^{-}(\text{aq})$ by periodate ions, $\text{IO}_4^{-}(\text{aq})$, according to the following equation.



The resulting solution was made up to a volume of 1.00 L, then 20.0 mL of this solution was diluted to 100.0 mL. The absorbance at 525 nm of the resulting solution was 0.50.

A calibration curve for $\text{MnO}_4^{-}(\text{aq})$ was constructed and is shown below.

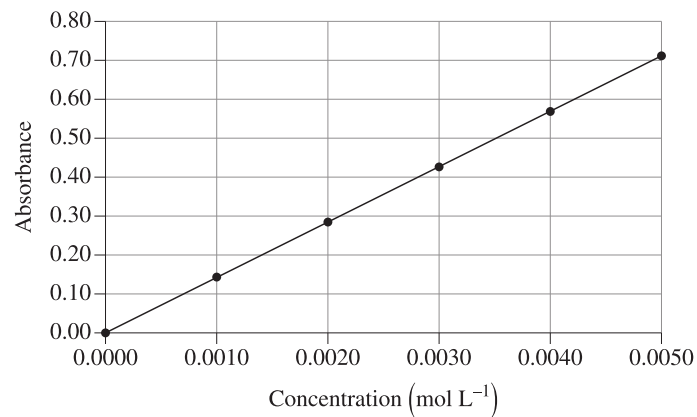


What was the percentage by mass of manganese in the steel sample?

- A. 0.019%
 - B. 0.096%
 - C. 0.48%
 - D. 1.0%
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22. CHEMISTRY, M8 2021 HSC 14 MC

A sample of nickel was dissolved in nitric acid to produce a solution with a volume of 50.00 mL. 10.00 mL of this solution was then diluted to 250.0 mL. This solution was subjected to colorimetric analysis. A calibration curve for this analysis is given.



The solution gave an absorbance value of 0.30.

What was the mass of the sample of nickel?

- A. 0.0021 g
- B. 0.031 g
- C. 0.053 g
- D. 0.15 g

23. CHEMISTRY, M8 2021 HSC 17 MC

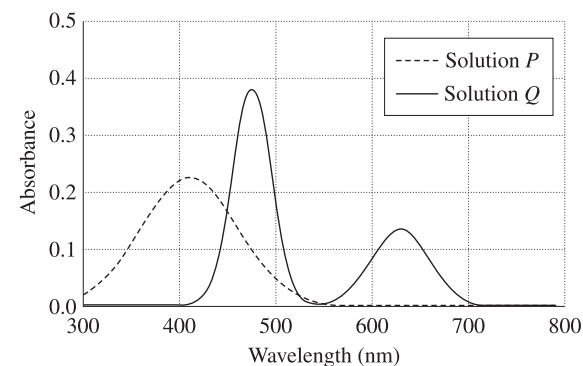
A sample was contaminated with sodium phosphate. The sample was dissolved in water and added to an excess of acidified $(\text{NH}_4)_2\text{MoO}_4$ to produce a precipitate of $(\text{NH}_4)_3\text{PO}_4 \cdot 12\text{MoO}_3$ ($MM = 1877 \text{ g mol}^{-1}$).

If 24.21 g of dry $(\text{NH}_4)_3\text{PO}_4 \cdot 12\text{MoO}_3$ was obtained, what was the mass of sodium phosphate in the original sample?

- A. 1.225 g
- B. 1.521 g
- C. 1.818 g
- D. 2.115 g

24. CHEMISTRY, M8 2022 HSC 6 MC

A UV-visible spectrometer was used to obtain the spectra of solutions of substances *P* and *Q*. The absorbance spectra are shown.



Which wavelength would be appropriate to determine the concentration of *Q* in a mixture of the two solutions?

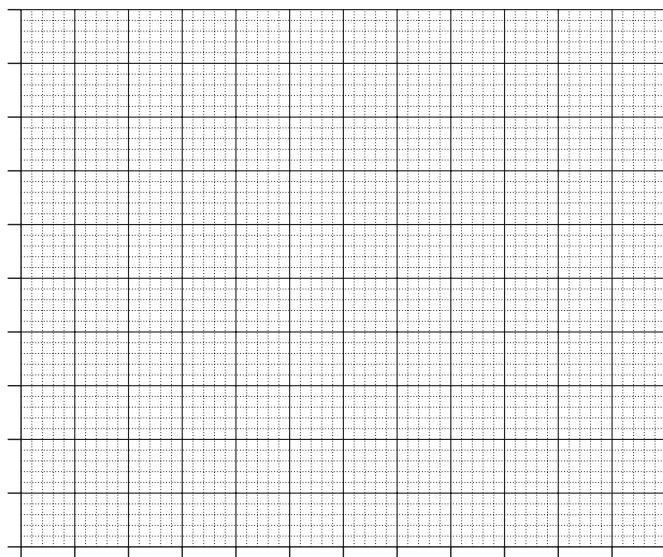
- A. 410 nm
- B. 475 nm
- C. 550 nm
- D. 630 nm

25. CHEMISTRY, M8 2017 HSC 22

Atomic absorption spectroscopy was used to determine the concentration of zinc in a water sample. The absorbance of a series of standard solutions of known concentration of zinc was measured. The results are shown in the table.

<i>Zinc concentration (ppm)</i>	0.00	1.00	2.00	3.00	4.00	5.00
<i>Absorbance</i>	0.00	0.17	0.34	0.48	0.65	0.83

a. Plot the data on the grid and draw a line of best fit. (3 marks)



b. In order for water to be considered safe for drinking, the concentration of zinc must be less than 2.80 ppm.

The absorbance of the water sample was 0.58. Explain whether this water is safe for drinking. (2 marks)

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26. CHEMISTRY, M5 EQ-Bank 26

The diagrams represent equipment used in an investigation to determine the chloride ion concentration in a water sample.

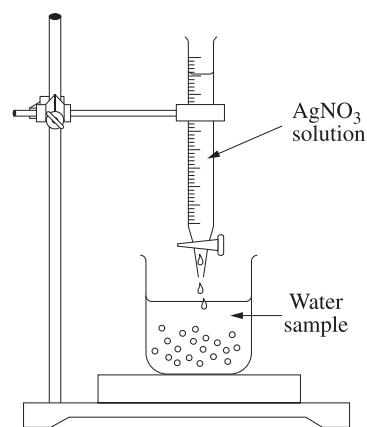


Figure 1

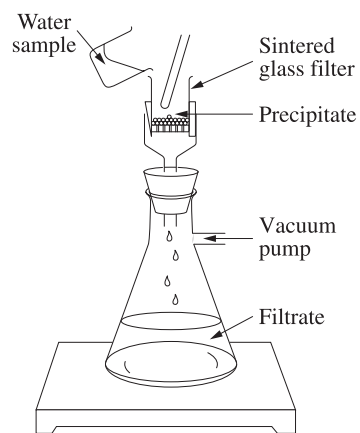


Figure 2

Describe how the chloride ion concentration in a water sample can be determined using the equipment in the diagrams. Include a relevant chemical equation. (3 marks)

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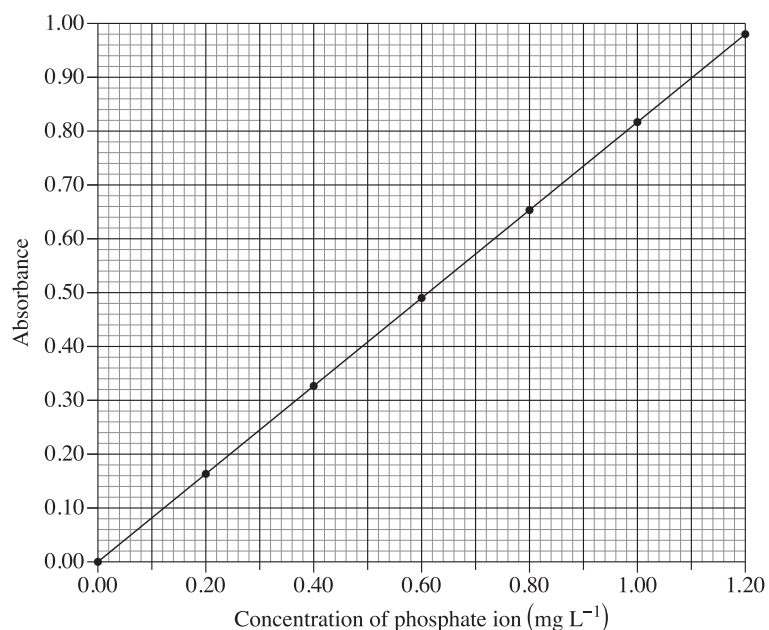
27. CHEMISTRY, M8 2024 HSC 25

The concentration of phosphate ions in washing machine waste water can be determined using colourimetry.

A sample of washing machine waste water was collected and diluted by quantitatively transferring 1.00 mL of the solution to a volumetric flask and making up the volume to 1.000 L with distilled water.

Standard phosphate solutions were prepared and analysed with a colourimeter using an accepted method.

The standard calibration graph is shown.



The diluted sample solution was then analysed using the same method as the standard solutions. The absorbance of this solution was found to be 0.64 .

Determine the concentration of phosphate ions in the sample of washing machine waste water, in mol L⁻¹. (4 marks)

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Calculate the percentage of iron in the tablet. (3 marks)

30. CHEMISTRY, M8 EQ-Bank 22

A bottle of solution is missing its label. It is either $\text{Pb}(\text{NO}_3)_2$, $\text{Ba}(\text{NO}_3)_2$ or $\text{Fe}(\text{NO}_3)_2$.

Using only HCl, NaOH and H₂SO₄ solutions, outline a sequence of steps that could be followed to confirm the identity of the solution in the bottle. Include observed results and ionic equations in your answer. (4 marks)

[illegible]

31. CHEMISTRY, M8 EQ-Bank 24

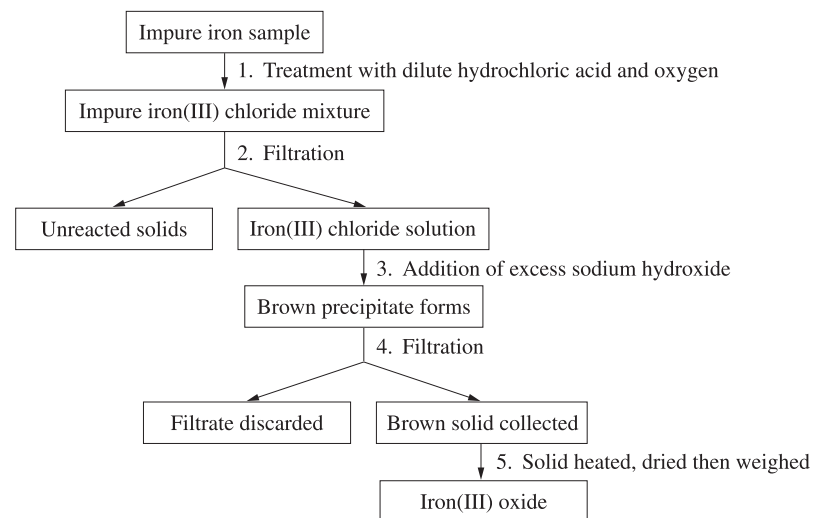
A common antacid tablet contains aluminium hydroxide to neutralise stomach acid. In order for the antacid to be effective, each 500 mg tablet must contain a minimum of 200 mg of aluminium hydroxide.

Two antacid tablets were crushed and reacted with 70 mL of 0.60 mol L^{-1} hydrochloric acid. After the antacid had reacted with the acid, the remaining hydrochloric acid was titrated against 0.60 mol L^{-1} sodium hydroxide. The average volume of sodium hydroxide used was 35 mL.

Calculate the amount of aluminium hydroxide present in each tablet and justify whether the tablets will be effective as an antacid. (4 marks)

32. CHEMISTRY, M8 2022 HSC 28

The iron content of an impure sample (4.32 g) was determined by the process shown in the flow chart.



a. Identify the brown precipitate formed at the end of step 3. (1 mark)

b. Calculate the percentage of iron in the original impure sample if 4.21 g of iron(III) oxide (Fe_2O_3) was collected. Assume that all the iron was converted to iron(III) oxide. (4 marks)

33. CHEMISTRY, M8 2012 VCE 6

The iron content in multivitamin tablets was determined using atomic absorption spectroscopy.

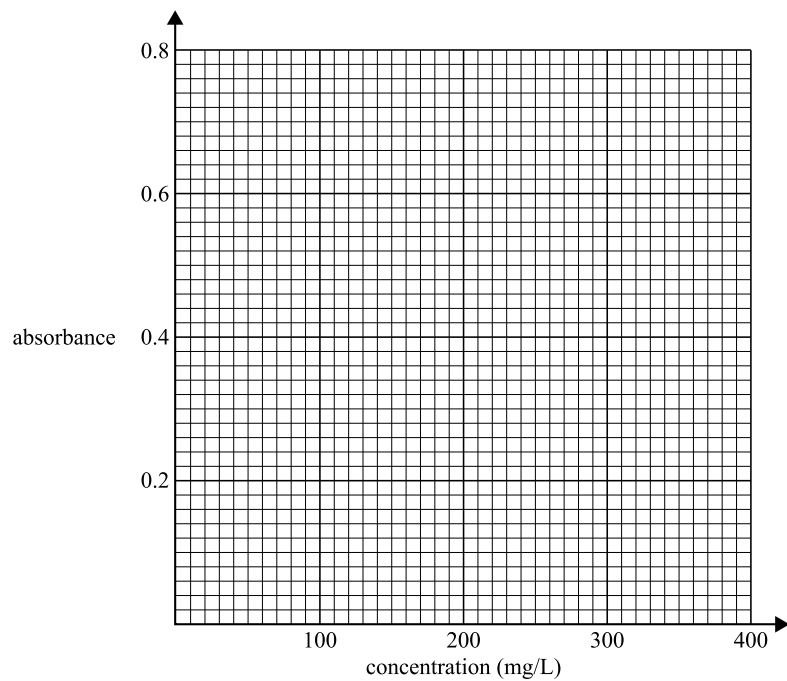
The absorbances of four standards were measured.

Three multivitamin tablets were selected. Each tablet was dissolved in 100.0 mL of water. The absorbance of each of the three solutions was then measured.

The following absorbances were obtained.

Solution	Concentration mg/L	Absorbance
Standard 1	0.00	0.06
Standard 2	100.0	0.16
Standard 3	200.0	0.25
Standard 4	300.0	0.36
Standard 5	400.0	0.46
Tablet 1	—	0.39
Tablet 2	—	0.42
Tablet 3	—	0.45

- a. i. Use the grid below to construct a calibration graph of the absorbances of the standard solutions. (2 marks)



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ii. How does this part of the electromagnetic spectrum interact with matter? What information does this spectroscopic technique provide? (2 marks)

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ii. Determine the average iron content, in milligrams, of the multivitamin tablets. (2 marks)

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Spectroscopic techniques work on the principle that, under certain conditions, atoms, molecules or ions will interact with electromagnetic radiation. The type of interaction depends on the wavelength of the electromagnetic radiation.

b. Name one spectroscopic technique that you have studied this year.

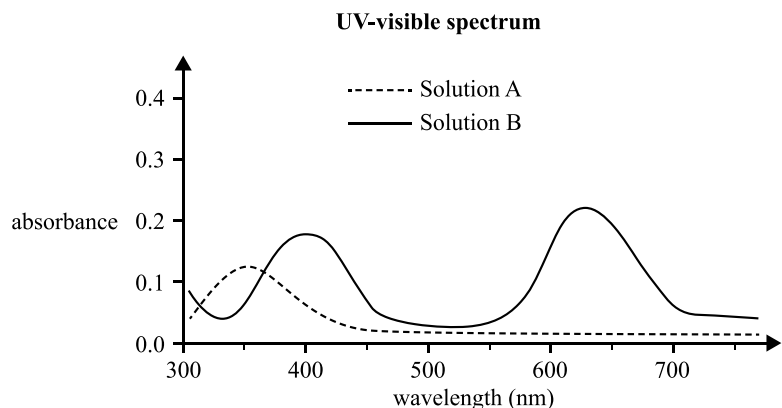
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i. Which part of the electromagnetic spectrum does this technique use? (1 mark)

34. CHEMISTRY, M8 2015 VCE 4

UV-visible spectroscopy was used to measure the spectra of two solutions, A and B. Solution A was a pink colour, while Solution B was a green colour.

The analyst recorded the absorbance of each solution over a range of wavelengths on the same axes. The resultant absorbance spectrum is shown below.



- a. If 10.00 mL of Solution A was mixed with 10.00 mL of Solution B, which wavelength should be used to measure the absorbance of Solution B in this mixture? Justify your answer. (2 marks)

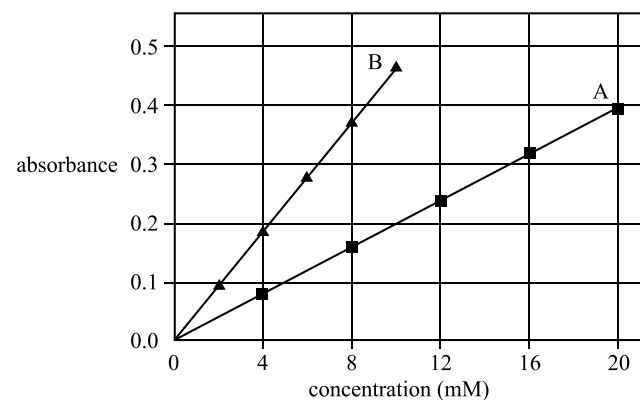
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The analyst used two sets of standard solutions and blanks to determine the calibration curves for the two solutions. The absorbances were plotted on the same axes. The graph is shown below.



- b. The analyst found that, when it was measured at the appropriate wavelength, Solution A had an absorbance of 0.2

If Solution A was cobalt(II) nitrate, $\text{Co}(\text{NO}_3)_2$, determine its concentration in mg L^{-1} (2 marks)

$$M(\text{Co}(\text{NO}_3)_2) = 182.9 \text{ g mol}^{-1} \quad 1 \text{ mM} = 10^{-3} \text{ M}$$

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- c. In another mixture, the pink compound in Solution A and the green compound in Solution B each have a concentration of approximately $1.5 \times 10^{-2} \text{ M}$.

Could the analyst reliably use both of the calibration curves to determine the concentrations for Solution A and Solution B by UV-visible spectroscopy? Justify your answer. (2 marks)

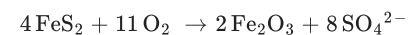
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35. CHEMISTRY, M8 2016 VCE 2*

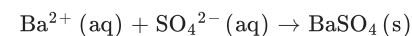
A common iron ore, fool's gold, contains the mineral iron pyrite, FeS_2 .

Typically, the percentage by mass of FeS_2 in a sample of fool's gold is between 90% and 95%. The actual percentage in a sample can be determined by gravimetric analysis.

The sulfur in FeS_2 is converted to sulfate ions, SO_4^{2-} as seen below:



This is then mixed with an excess of barium chloride, BaCl_2 , to form barium sulfate, BaSO_4 , according to the equation



When the reaction has gone to completion, the BaSO_4 precipitate is collected in a filter paper and carefully washed. The filter paper and its contents are then transferred to a crucible. The crucible and its contents are heated until constant mass is achieved.

The data for an analysis of a mineral sample is as follows.

initial mass of mineral sample	14.3 g
mass of crucible and filter paper	123.40 g
mass of crucible, filter paper and dry BaSO_4	174.99 g
$M(\text{FeS}_2)$	120.0 g mol^{-1}
$M(\text{BaCl}_2)$	208.3 g mol^{-1}
$M(\text{BaSO}_4)$	233.4 g mol^{-1}

a. Calculate the percentage by mass of FeS_2 in this mineral sample. (4 marks)

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36. CHEMISTRY, M8 2018 HSC 22

A bottle of solution is missing its label. It is either $\text{Pb}(\text{NO}_3)_2$, $\text{Ba}(\text{NO}_3)_2$ or $\text{Fe}(\text{NO}_3)_2$

Using only HCl , NaOH and H_2SO_4 solutions, outline a sequence of steps that could be followed to confirm the identity of the solution in the bottle. Include observed results and ionic equations in your answer. (4 marks)

b. State one assumption that was made in completing the calculations for this analysis. (1 mark)

37. CHEMISTRY, M8 2020 HSC 22

A 0.1 mol L⁻¹ solution of an unknown salt is to be analysed. The cation is one of magnesium, calcium or barium. The anion is one of chloride, acetate or hydroxide.

Outline a sequence of tests that could be performed in a school laboratory to confirm the identity of this salt solution. Include expected observations and a balanced chemical equation in your answer. (5 marks)

[illegible]

38. CHEMISTRY, M8 2021 HSC 30

A student was trying to identify the ions present in a dilute aqueous solution.

The solution contained ions of barium, calcium or magnesium, and ions of hydroxide or acetate.

The student performed the following tests and recorded their observations. A fresh sample of the solution was used for each test.

- When aqueous sodium chloride was added, no visible reaction was observed.
- When aqueous silver nitrate was added, brown precipitate was produced. The precipitate dissolved when dilute hydrochloric acid was added.
- When concentrated aqueous sodium sulfate was added, white precipitate was produced.

Evaluate this procedure as a method of identifying the ions. (5 marks)

[illegible]

39. CHEMISTRY, M8 2015 HSC 29

The procedure of a first-hand investigation conducted in a school laboratory to determine the percentage of sulfate in a lawn fertiliser is shown.

- 2.00 g of a sample of fertiliser was ground up and placed in a beaker.
- It was dissolved in about 200 mL of 0.1 mol L^{-1} hydrochloric acid, stirred and filtered.
- Excess barium chloride solution was quickly added to this beaker and a precipitate formed.
- The precipitate was then allowed to settle, filtered using filter paper and the residue collected.
- The residue was dried and weighed and had a mass of 2.23 g.

a. Suggest modifications that could be made to the procedure to improve the results of this investigation. Justify your suggestions. (4 marks)

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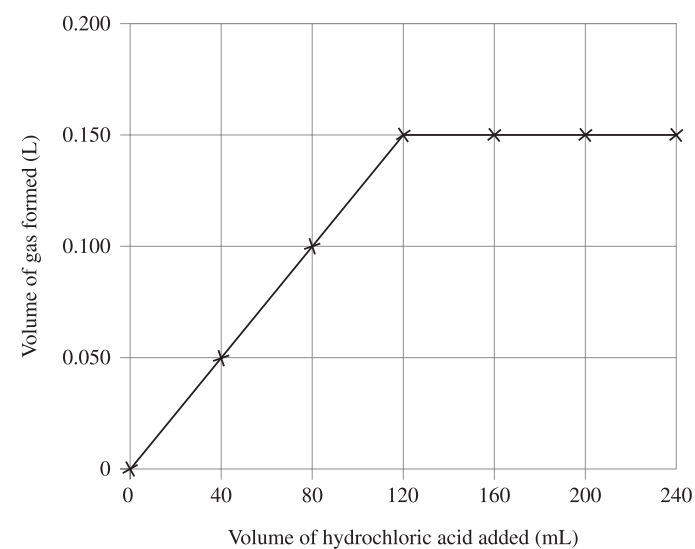
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b. Calculate the percentage of sulfate in the original fertiliser sample. (3 marks)

40. CHEMISTRY, M8 2016 HSC 27

The volume of gas formed at 25°C and 100 kPa as hydrochloric acid was added to a pure sample of aluminium is shown in the graph.

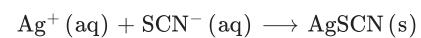


Calculate the original mass of the aluminium sample used in the reaction. (4 marks)

41. CHEMISTRY, M8 2020 HSC 31

A water sample was analysed to determine the chloride ion content. 100.0 mL of this water was added to 25.00 mL of 0.100 mol L⁻¹ AgNO₃ (aq).

The mixture was filtered and the filtrate was titrated against $0.0500 \text{ mol L}^{-1} \text{ KSCN (aq)}$ according to the following reaction.



The titration was repeated three times and the average titre was 28.65 mL.

Calculate the concentration of chloride ions in the water, expressed in mg L^{-1} . (4 marks)

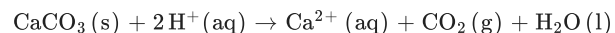
[illegible]

44. CHEMISTRY, M8 2013 VCE 2

The strength of the eggshell of birds is determined by the calcium carbonate, CaCO_3 , content of the eggshell.

The percentage of calcium carbonate in the eggshell can be determined by gravimetric analysis.

0.412 g of clean, dry eggshell was completely dissolved in a minimum volume of dilute hydrochloric acid.



An excess of a basic solution of ammonium oxalate, $(\text{NH}_4)_2\text{C}_2\text{O}_4$, was then added to form crystals of calcium oxalate monohydrate, $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$.

The suspension was filtered and the crystals were then dried to constant mass.

0.523 g of $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$ was collected.

- a. Write a balanced equation for the formation of the calcium oxalate monohydrate precipitate. (1 mark)

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- b. Determine the percentage, by mass, of calcium carbonate in the eggshell. (3 marks)

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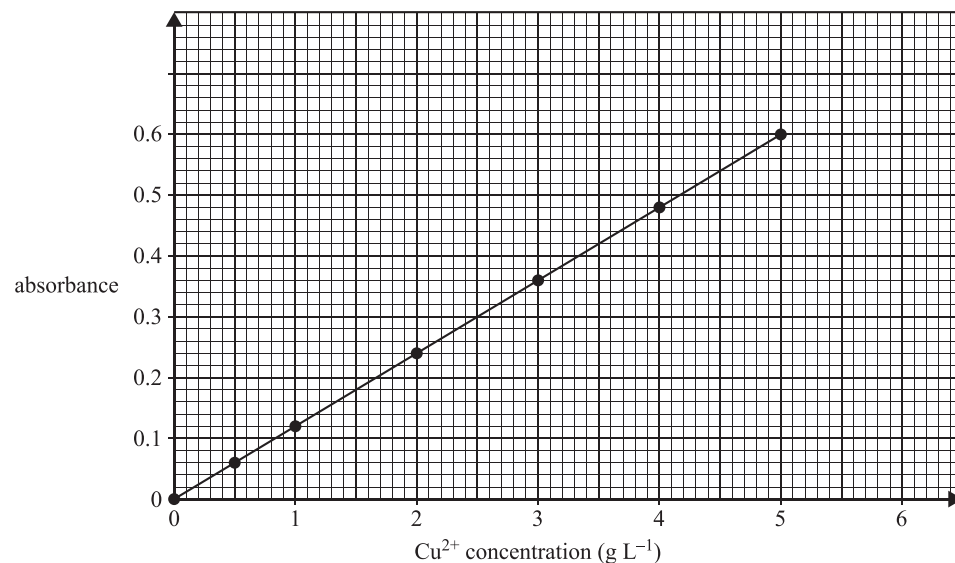
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45. CHEMISTRY, M8 2016 VCE 6

Brass is an alloy of copper and zinc.

To determine the percentage of copper in a particular sample of brass, an analyst prepared a number of standard solutions of copper(II) ions and measured their absorbance using an atomic absorption spectrometer (AAS).

The calibration curve obtained is shown below.



- a. A 0.198 g sample of the brass was dissolved in acid and the solution was made up to 100.00 mL in a volumetric flask. The absorbance of this test solution was found to be 0.13

Calculate the percentage by mass of copper in the brass sample. (3 marks)

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46. CHEMISTRY, M8 EQ-Bank 28

Limestone (CaCO_3) contributes to the hardness of water by releasing Ca^{2+} ions. The following chemical equation represents this reaction.



It has been suggested that heating water reduces its hardness.

Explain how this suggestion can be tested accurately, validly and reliably. (9 marks)

[illegible][illegible]

47. CHEMISTRY, M8 2019 HSC 29

Stormwater from a mine site has been found to be contaminated with copper(II) and lead(II) ions. The required discharge limit is 1.0 mg L⁻¹ for each metal ion. Treatment of the stormwater with Ca(OH)₂ solid to remove the metal ions is recommended.

a. Explain the recommended treatment with reference to solubility. Include a relevant chemical equation. (2 marks)

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b. Explain why atomic absorption spectroscopy can be used to determine the concentrations of Cu²⁺ and Pb²⁺ ions in a solution containing both species. (2 marks)

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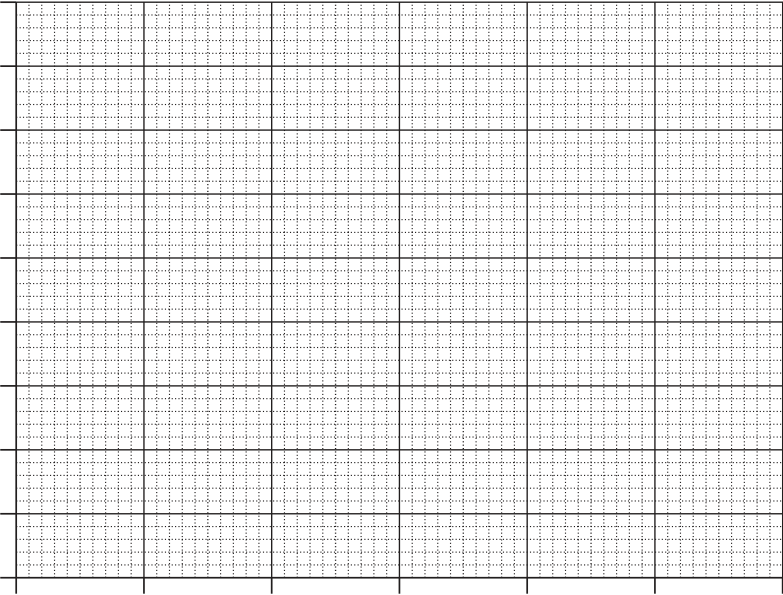
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c. The data below were obtained after treatment of the stormwater.

Data from atomic absorption spectroscopy		
Concentration (× 10 ⁻⁵ mol L ⁻¹) Cu ²⁺ or Pb ²⁺	Absorbance	
	Cu ²⁺	Pb ²⁺
0.0	0.000	0.000
1.0	0.140	0.090
2.0	0.310	0.180
4.0	0.520	0.390
6.0	0.840	0.530
Water sample before treatment	0.820	0.440
Water sample after treatment	0.040	0.080

To what extent is the treatment effective in meeting the required discharge limit of 1.0 mg L⁻¹ for each metal ion? Support your conclusion with calibration curves and calculations. (7 marks)



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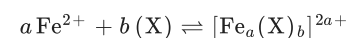
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48. CHEMISTRY, M8 EQ-Bank 23

Fe^{2+} and X react to form an ionic compound according to the general equation

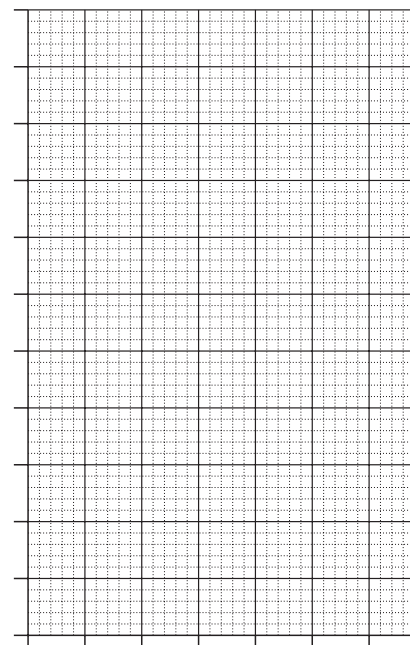


where a and b are numbers representing the ratio in which Fe^{2+} and X combine.

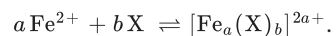
Spectrophotometry was used to determine the stoichiometric ratio between Fe^{2+} and X. To do this, eight 10 mL samples were prepared by reacting solutions of Fe^{2+} with solutions of X in varying ratios. All Fe^{2+} and X solutions had the same concentration. The absorbance of the samples is tabulated below.

	<i>Samples</i>							
Volume of Fe^{2+} solution (mL)	0.00	1.00	2.00	3.00	4.00	5.00	6.00	10.00
Volume of X solution (mL)	10.00	9.00	8.00	7.00	6.00	5.00	4.00	0.00
Absorbance at 508 nm	0.00	0.42	0.84	0.98	0.84	0.70	0.56	0.00

- a. On the grid, construct a graph of absorbance against volume of Fe^{2+} solution from 0.00 mL to 6.00 mL, and draw TWO lines of best fit. (3 marks)



- b. The reaction proceeds according to the general equation



Find the values of a and b . Justify your answer with reference to the data given and the graph in part (a). (3 marks)

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Worked Solutions

1. CHEMISTRY, M8 2018 HSC 4 MC

→ AAS allows trace elements to be detected at much lower concentrations than previous techniques.

⇒ B

2. CHEMISTRY, M8 2013 VCE 8* MC

→ AAS is the only analytical technique that is specific to identifying metals within a solution.

⇒ C

3. CHEMISTRY, M8 2015 HSC 3 MC

Copper ions produce a blue-green flame colour.

⇒ B

4. CHEMISTRY, M8 2017 HSC 2 MC

Consider each option:

→ Barium ions produce blue-green (incorrect)

→ Calcium ions produce orange-red (incorrect)

→ Carbonate ions produce no colour (incorrect)

→ Copper ions produce blue-green (correct)

⇒ D

5. CHEMISTRY, M8 2022 HSC 5 MC

By elimination:

→ Silver and Magnesium do not emit visible wavelengths of light. (A is incorrect)}

→ The flame test only works on metals (C is incorrect)

→ Ions of the same element but different oxidation states cannot be distinguished using the flame test (D is incorrect)

→ In a flame test Ba^{2+} has an apple-green flame colour whilst Ca^{2+} has a brick-red flame colour, and thus can be distinguished. (B is correct)

⇒ B

6. CHEMISTRY, M8 2024 HSC 8 MC

→ Only metal cations produce unique colours during a flame test due to their electron configurations.

→ As the electrons 'fall back' down into their shells from an excited state, they emit a specific light wave (colour).

⇒ C

7. CHEMISTRY, M8 2016 HSC 13 MC

By Elimination:

→ Sodium produces a bright yellow-orange colour in a flame test (eliminate C and D)

→ No gas is produced when sulphate reacts with acid (eliminate B)

⇒ A

8. CHEMISTRY, M8 2016 HSC 19 MC

$$n(\text{Na}_2\text{SO}_4) = c \times V = 0.2 \times 0.2 = 0.04 \text{ mol}$$

$$n(\text{BaSO}_4) = 0.04 \text{ mol (1: 1 mole ratio)}$$

$$n(\text{Ba}_2\text{SO}_4) = n \times \text{MM} = 0.04 \times (137.3 + 32.07 + 16 \times 4) = 9.3348 \text{ g} = 9.33 \text{ (3 sig fig)}$$

⇒ C

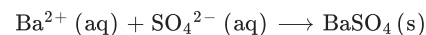
9. CHEMISTRY, M8 2017 HSC 19 MC

$$m(\text{SO}_4^{2-}) = 0.48 \times 1.20 = 0.576 \text{ g}$$

$$n(\text{SO}_4^{2-}) = \frac{m}{\text{MM}} = \frac{0.576}{32.07 + 4 \times 16.00} = 5.996 \times 10^{-3} \text{ mol}$$

Mean mark 57%.

Chemical equation



$$n(\text{BaSO}_4) = n(\text{SO}_4^{2-}) = 5.996 \times 10^{-3} \text{ mol}$$

$$m(\text{BaSO}_4) = n \times \text{MM} = (5.996 \times 10^{-3}) \times 233.37 = 1.40 \text{ g}$$

⇒ C

10. CHEMISTRY, M8 2021 HSC 2 MC

Silver Nitrate → Ag^+ and NO_3^-

Solubility rules → all nitrates are soluble

→ Ag^+ is involved in the precipitation reaction

→ Ag^+ will form a precipitate with Cl^-

⇒ B

11. CHEMISTRY, M8 2022 HSC 4 MC

Consider Option C:

→ The emission spectrum of this lamp emits wavelengths of light that correspond to the absorption spectrum of Mn.

→ This lamp would be best used to determine the Mn concentration because it will emit wavelengths of light that are only absorbed by Mn.

⇒ C

12. CHEMISTRY, M8 2023 HSC 13 MC

⇒ A

13. CHEMISTRY, M8 2023 HSC 2 MC

By elimination:

→ Although a flame test uses a flame to analyse chemical samples, it does not require a detector, prism, lamp or lens. Hence it is not the analytical method being demonstrated in the above diagram (eliminate A).

→ Mass Spectroscopy is used for organic compounds and requires an electromagnet which is not present in the above diagram (eliminate B).

→ Atomic Absorption Spectroscopy (used for inorganic compounds) is based on the idea that atoms can absorb light at a specific unique wavelength. The above image demonstrates this.

→ Ultraviolet-visible Spectrophotometry: although this uses the same principle as AAS to detect sample concentration, Ultraviolet-visible Spectrophotometry uses a different wavelength of light and requires a different apparatus to the one in the diagram above (eliminate D).

⇒ C

14. CHEMISTRY, M8 2015 HSC 18-19 MC

Question 18

⇒ A

Question 19

$$n(\text{PbCl}_2) = \frac{0.13}{207.2 + 2 \times 35.45} = \frac{0.13}{278.1} = 4.67 \times 10^{-4} \text{ mol}$$

$$n(\text{Pb}^{2+}) = n(\text{PbCl}_2) = 4.67 \times 10^{-4} \text{ mol}$$

$$[\text{Pb}^{2+}] = \frac{4.67 \times 10^{-4}}{0.050} = 9.3 \times 10^{-3} \text{ mol L}^{-1}$$

⇒ C

♦ Mean mark (Q19)
52%.

15. CHEMISTRY, M8 2014 VCE 16-17 MC

Question 16

→ The concentration of copper ions will be most accurate on the calibration curve in between the limits of the concentration of standard solutions used to produce the calibration curve.

→ Thus it will be most accurate between 1.0 ppm and 4.0 ppm.

⇒ C

Question 17

From the graph: Absorbance of 0.4 → 2.5 ppm (2.5 g L^{-1})

$$M(\text{copper ions}) = 63.55 \text{ g mol}^{-1}$$

$$c(\text{copper ions}) = 2.5 \times 10^{-3} \text{ g L}^{-1} = \frac{2.5 \times 10^{-3}}{63.55} = 3.9 \times 10^{-5} \text{ mol L}^{-1}$$

⇒ C

♦ Mean mark (Q17)
49%.

16. CHEMISTRY, M5 2023 HSC 16 MC

→ This procedure is only correct and valid if the ions precipitated out at different times.

→ Therefore AgI would precipitate out first as it is less soluble than AgCl.

⇒ B

♦ Mean mark 41%.

17. CHEMISTRY, M8 2022 HSC 16 MC

→ Consider Beer-Lambert law, $A = \epsilon lc$.

→ As the pathlength (l) increases, the absorbance (A) increases.

⇒ D

♦ Mean mark 45%.

18. CHEMISTRY, M8 2017 HSC 8 MC

→ If sodium chloride is added to barium nitrate, barium chloride (soluble) is formed but no precipitate results.

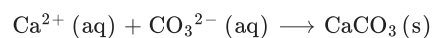
♦ Mean mark 49%.

→ If sodium chloride is added to lead nitrate, lead chloride (insoluble) is formed and a precipitate results.

→ All other options will produce either a precipitate or no precipitate in both solutions and not distinguish between them.

⇒ C

19. CHEMISTRY, M8 2018 HSC 16 MC



$$n(\text{CaCO}_3) = \frac{m}{\text{MM}} = \frac{0.400}{100.09} = 3.9964 \times 10^{-3} \text{ mol}$$

♦ Mean mark 41%.

$$n(\text{Ca}^{2+}) = n(\text{CaCO}_3) = 3.9964 \times 10^{-3} \text{ mol}$$

$$m(\text{Ca}^{2+}) = n \times \text{MM} = 3.9964 \times 10^{-3} \times 40.08 = 160 \text{ mg}$$

$$\therefore [\text{Ca}^{2+}] = \frac{160}{2.0} = 80 \text{ mg L}^{-1}$$

⇒ A

20. CHEMISTRY, M8 2018 HSC 20 MC

Consider Step 3:

$$n(\text{I}_2) = \frac{1}{2} \times n(\text{S}_2\text{O}_3^{2-}) = \frac{1}{2} \times 4.00 \times 10^{-3} = 2 \times 10^{-3} \text{ mol}$$

♦ Mean mark 45%.

Consider Step 2:

$$n(\text{MnO}(\text{OH})_2) = n(\text{I}_2) = 2 \times 10^{-3} \text{ mol}$$

Consider Step 1:

$$n(\text{O}_2) = \frac{1}{2} \times n(\text{MnO}(\text{OH})_2) = \frac{1}{2} \times 2.00 \times 10^{-3} = 1 \times 10^{-3} \text{ mol}$$

$$\therefore [\text{O}_2] = \frac{n}{V} \times \text{MM} = \frac{1 \times 10^{-3}}{5.0} \times 32 = 0.0064 \text{ g L}^{-1}$$

⇒ B

21. CHEMISTRY, M8 2019 HSC 20 MC

From graph, 0.5 absorbance corresponds to 0.25 mg L^{-1} .

$$[\text{MnO}_4^-]_{\text{dilute}} = \frac{25 \times 10^{-3}}{54.94 + 16 \times 4} \\ = 2.1019 \times 10^{-4} \text{ mol L}^{-1}$$

$$[\text{MnO}_4^-]_{\text{conc}} = 2.1019 \times 10^{-4} \times \frac{1}{2} \\ = 1.05095 \times 10^{-3} \text{ mol L}^{-1}$$

$$n(\text{MnO}_4^-) = c \times V = 1.05095 \times 10^{-3} \times 1 = 1.05095 \times 10^{-3} \text{ mol}$$

$$n(\text{Mn}^{2+}) = n(\text{MnO}_4^-) = 1.05095 \times 10^{-3} \text{ mol}$$

$$m(\text{Mn}^{2+}) = n \times \text{MM} \\ = 1.05095 \times 10^{-3} \times 54.94 \\ = 5.774 \times 10^{-3} \text{ g}$$

$$\therefore \text{Mn}^{2+}(\%) = \frac{5.774 \times 10^{-3}}{12.0} \times 100\% = 0.48\%$$

$\Rightarrow C$

♦♦ Mean mark 43%.

22. CHEMISTRY, M8 2021 HSC 14 MC

Absorbance = 0.30

From the calibration curve, an absorbance of 0.30 corresponds to a $[\text{Ni}_2^+]$ of $0.0021 \text{ mol L}^{-1}$.

$$n(\text{Ni}^{2+}) = 0.0021 \text{ mol L}^{-1}$$

$$n(\text{Ni}^{2+})_{\text{diluted}} = c \times V \\ = 0.0021 \times 0.250 \\ = 0.000525 \text{ mol}$$

This is the moles of Ni^{2+} in the diluted sample, which contained only 10.0 mL of the initial 50.0 mL of the original solution.

Thus, in order to find the number of moles in the original sample, multiply the number of moles by 5.

$$n(\text{Ni}^{2+})_{\text{undiluted}} = 5 \times 0.000525 = 0.002625 \text{ mol}$$

$$n(\text{Ni}^{2+}) = \frac{m}{\text{MM}}$$

$$m(\text{Ni}^{2+}) = n \times \text{MM} \\ = 0.002625 \times 58.69 \\ = 0.15406125 \dots \\ = 0.15 \text{ g (2 d.p.)}$$

$\Rightarrow D$

♦♦ Mean mark 38%.

23. CHEMISTRY, M8 2021 HSC 17 MC

$$\begin{aligned} n((\text{NH}_4)_3\text{PO}_4 \cdot 12\text{MoO}_3) &= \frac{m}{\text{MM}} \\ &= \frac{24.21}{1877} \\ &= 0.01289 \dots \text{ moles} \end{aligned}$$

♦♦ Mean mark 36%.

Each precipitate molecule has one molecule of PO_4^{3-}

Each Na_3PO_4 molecule has one molecule of PO_4^{3-}

$$\rightarrow n(\text{Na}_3\text{PO}_4) = n((\text{NH}_4)_3\text{PO}_4 \cdot 12\text{MoO}_3)$$

$$\rightarrow n(\text{Na}_3\text{PO}_4) = \frac{m}{\text{MM}}$$

$$\begin{aligned} m(\text{Na}_3\text{PO}_4) &= n \times \text{MM} \\ &= 0.01289 \dots \times (3 \times 22.99 + 30.97 + 4 \times 16) \\ &= 2.115 \text{ g} \end{aligned}$$

$\Rightarrow D$

24. CHEMISTRY, M8 2022 HSC 6 MC

\rightarrow The most appropriate wavelength would be a wavelength that is mostly absorbed by Q but minimally interfered with by P .

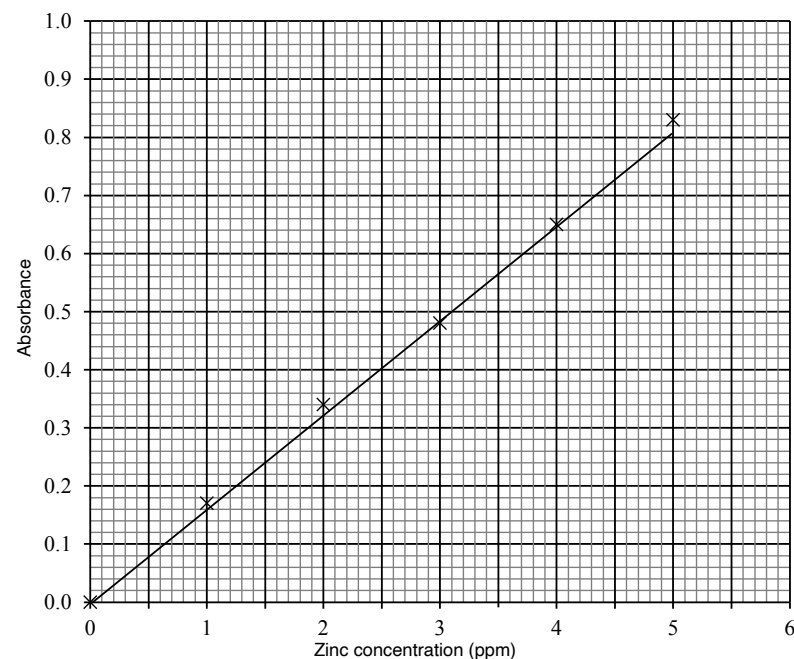
♦ Mean mark 41%.

\rightarrow Thus, the best wavelength is 630 nm because is a significant absorbance by Q , and an insignificant absorbance by P .

$\Rightarrow D$

25. CHEMISTRY, M8 2017 HSC 22

a.



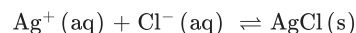
b. Using the line of best fit above:

\rightarrow 0.58 absorbance (y-axis) \sim 3.6 ppm of zinc concentration

\rightarrow Since 3.6 ppm $>$ 2.8 ppm (safe level), the water is not safe to drink.

26. CHEMISTRY, M5 EQ-Bank 26

→ When the silver nitrate solution is added, chloride ions present in the water sample will precipitate with the added silver ions described by the following equation:



→ Adding excess silver nitrate ensures all chloride ions precipitate out.

→ The filtering apparatus is used to filter solid silver chloride. This solid is then dried to constant mass and weighed.

→ Using the molar mass of silver chloride, the number of moles of solid silver chloride produced is calculated. Silver chloride contains silver ions and chloride ions in a 1:1 molar ratio and using this ratio, the moles of chloride present is calculated.

→ The result represents the same number of moles of chloride in the original water sample. Using the volume of the water sample, its chloride ion concentration is calculated.

27. CHEMISTRY, M8 2024 HSC 25

→ Absorbance value of 0.64 = diluted concentration of 0.78 mg L^{-1} .

→ As the sample was originally diluted by a factor of 1000

$$\text{Original concentration} = 0.78 \times 1000 = 780 \text{ mg L}^{-1} = 0.78 \text{ g L}^{-1}$$

$$\rightarrow \text{MM}(\text{PO}_4^{3-}) = 30.97 + 4(16.00) = 94.97 \text{ g mol}^{-1}$$

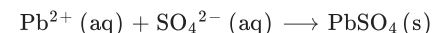
$$\rightarrow [\text{PO}_4^{3-}] = \frac{0.78}{94.97} = 8.2 \times 10^{-3} \text{ mol L}^{-1}$$

28. CHEMISTRY, M8 2024 HSC 27

Barium and lead(II) ions both present:

→ The procedure gives the incorrect results as both of these ions form precipitates with sulfate ions in step one.

→ Although barium sulfate has a lower solubility in water than lead sulfate and would precipitate out of the solution first, there is the potential for all of the lead ions to also precipitate out of solution according to the following chemical equation:



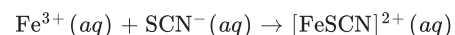
→ At step three, there would be no precipitate formed as all the lead ions would have been precipitated out of the solution during step one, leading to an incorrect conclusion.

Barium ions only present:

→ If only barium ions are present in the original sample, they will precipitate out of the solution in the presence of the sulfate ions in step one but will not form a precipitate in step three in the presence of bromide ions.

→ In this case, the conclusion that only Ba^{2+} ions are in the sample is correct.

29. CHEMISTRY, M8 EQ-Bank 12



Using the graph:

Absorbance = 0.615

$$\rightarrow \text{Initial } [\text{Fe}^{3+}] \text{ in } 200 \text{ mL} = 55 \times 10^{-6} = 5.5 \times 10^{-5} \text{ mol L}^{-1}$$

$$n(\text{Fe}^{3+}) = c \times V = 5.5 \times 10^{-5} \times 0.2 = 1.1 \times 10^{-5} \text{ mol}$$

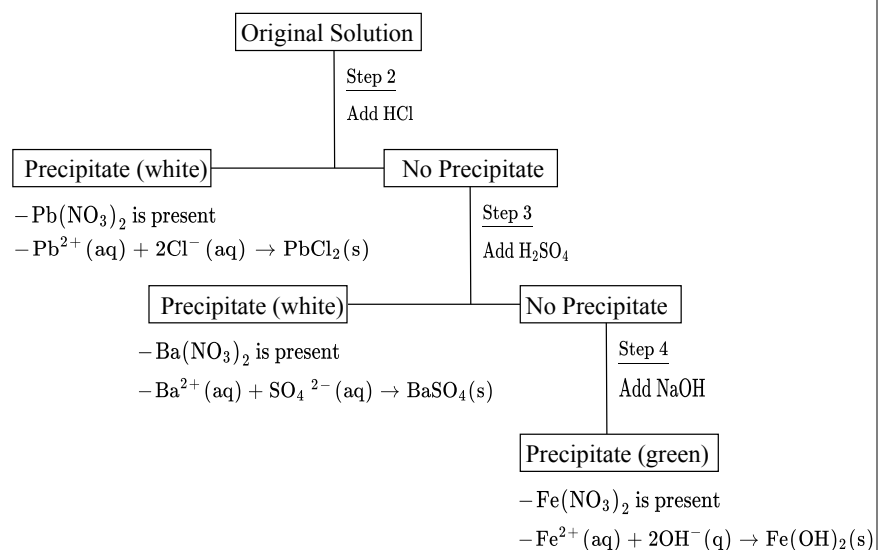
$$\text{MM}(\text{Fe}) = 55.85 \text{ g mol}^{-1}$$

$$m(\text{Fe}) = 1.1 \times 10^{-5} \times 55.85 = 6.14 \times 10^{-4} \text{ g}$$

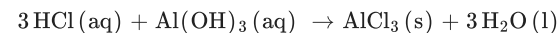
$$\therefore \% \text{ Fe} = \frac{6.14 \times 10^{-4}}{0.200} \times 100 = 0.307 \%$$

30. CHEMISTRY, M8 EQ-Bank 22

Step 1: Prepare samples of the original solution and HCl, NaOH and H₂SO₄ solutions and then follow the flow chart below.



31. CHEMISTRY, M8 EQ-Bank 24



$$n(\text{HCl}^-) = c \times V = 0.6 \times 0.070 = 0.042 \text{ mol}$$

$$n(\text{Na(OH)}) = c \times V = 0.6 \times 0.035 = 0.021 \text{ mol}$$

$$\text{Moles reacted with antacid} = 0.042 - 0.021 = 0.021 \text{ mol}$$

$$\text{Mole ratio} = 3 : 1$$

$$\text{Moles of Al(OH)}_3 \text{ in 2 tablets} = \frac{0.021}{3} = 0.007 \text{ mol}$$

$$\text{Formula weight of Al(OH)}_3 = 27 + 3 \times (1 + 16) = 78 \text{ g}$$

$$m(\text{Al(OH)}_3) \text{ in 2 tablets} = 0.007 \times 78 = 0.546 \text{ g}$$

$$m(\text{Al(OH)}_3) \text{ in 1 tablet} = \frac{0.546}{2} = 273 \text{ g}$$

Since 273 > 200, tablets will be effective.

32. CHEMISTRY, M8 2022 HSC 28

a. Fe(OH)₃

$$\begin{aligned} \text{b. } n(\text{Fe}_2\text{O}_3) &= \frac{m}{\text{MM}} \\ &= \frac{4.21}{2 \times 55.85 + 3 \times 16.00} \\ &= 0.0264 \text{ mol} \end{aligned}$$

$$n(\text{Fe}) = 2 \times n(\text{Fe}_2\text{O}_3) = 0.0527 \text{ mol}$$

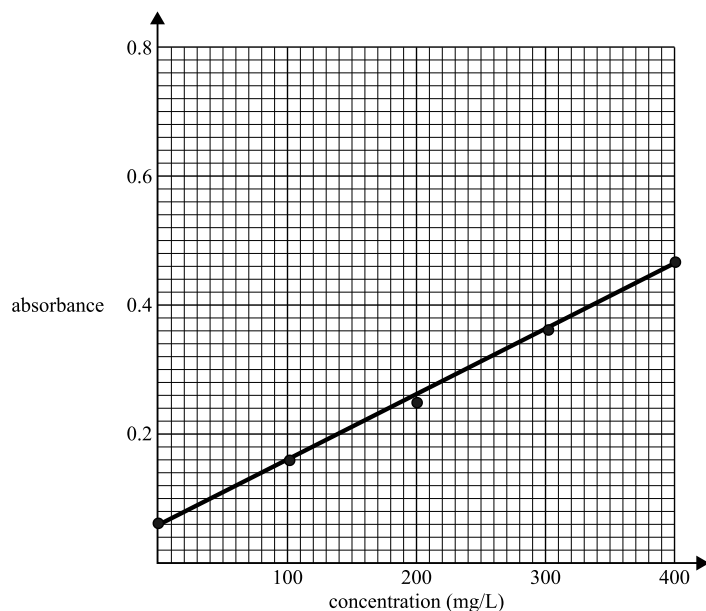
$$m(\text{Fe}) = n \times \text{MM} = 0.0527238 \times 55.85 = 2.94 \text{ g}$$

$$\begin{aligned} \text{Fe(\%)} &= \frac{m(\text{Fe})}{m(\text{original sample})} \times 100 \% \\ &= \frac{2.944627}{4.32} \times 100 \% \\ &= 68.2 \% \end{aligned}$$

Therefore, the percentage of iron in the original impure sample is 68.2%.

33. CHEMISTRY, M8 2012 VCE 6

a.i.



a.ii. Average absorbance (tablets) = $\frac{0.39 + 0.42 + 0.45}{3} = 0.42$

Using the graph: absorbance value of 0.42 \rightarrow 355 mg L⁻¹

$m(\text{Fe}) (100 \text{ ml}) = 355 \times 0.1 = 35.5 \text{ mg}$

b.i. Answers could include:

- \rightarrow AAS (visible light)
- \rightarrow UV-Vis (UV or visible light)
- \rightarrow IR (Infrared radiation)
- \rightarrow NMR (radiowaves)

b.ii. Spectroscopic technique: AAS (one of many possible – see b.i.)

- \rightarrow During AAS energy of a certain frequency is transferred to electrons within atoms to move them into higher energy levels.
- \rightarrow The absorption of the light indicates the concentration of the targeted element within the sample.

♦ Mean mark (b.ii) 42%.

34. CHEMISTRY, M8 2015 VCE 4

a. \rightarrow Wavelength: 625 nm (600 to 650 was accepted)

\rightarrow At this wavelength there is the maximum absorbance of solution B with no significant absorbance (interference) from solution A.

b. From the graph:

Absorbance of 0.2 $\Rightarrow 10 \times 10^{-3} \text{ mol L}^{-1}$

$n(\text{Co}(\text{NO}_3)_2) = 10 \times 10^{-3} \times 182.9 = 1.829 \text{ g L}^{-1} = 1.8 \times 10^3 \text{ mg L}^{-1}$

c. $\rightarrow 1.5 \times 10^{-2} \text{ M} = 15 \text{ mM}$.

♦♦ Mean mark (c) 30%.

\rightarrow This value lies within the calibration curve for solution A, so the calibration curve can be used to determine the concentration of solution A.

\rightarrow This value lies beyond the calibration curve for solution B, therefore the curve can't be used to determine the concentration of solution B. The analyst would need to extrapolate the curve but this would not be reliable.

35. CHEMISTRY, M8 2016 VCE 2*

a. $m(\text{BaSO}_4 \text{ final}) = 174.99 - 123.40 = 51.59 \text{ g}$

$$n(\text{BaSO}_4 (\text{s})) = \frac{51.59}{233.4} = 0.221 \text{ mol}$$

$$\Rightarrow n(\text{SO}_4^{2-} (\text{aq})) = 0.221 \text{ mol}$$

$$\text{Molar ratio } \text{FeS}_2 : \text{SO}_4^{2-} = 1 : 2$$

$$\Rightarrow n(\text{FeS}_2) = 0.221 \times \frac{1}{2} = 0.1105 \text{ mol}$$

$$m(\text{FeS}_2) = 0.1105 \times 120.0 = 13.26 \text{ g}$$

$$\% \text{FeS}_2 = \frac{13.26}{14.3} \times 100 = 92.7\% \text{ (3 sig.fig.)}$$

b. Answers could have included one of the following:

→ All the sulfur is converted to SO_4^{2-} .

→ Precipitate was pure.

→ No BaSO_4 was lost in washing the sample.

→ BaSO_4 was the only precipitate.

→ The sample was fully dehydrated.

♦ Mean mark (b) 39%.

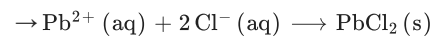
36. CHEMISTRY, M8 2018 HSC 22

Prepare 1 test tube of the unknown solution.

Step 1: Add HCl to the solution.

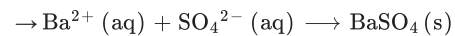
Mean mark 56%.

→ If a white precipitate forms, $\text{Pb}(\text{NO}_3)_2$ is present.



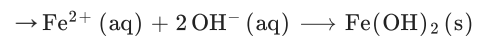
Step 2: Add H_2SO_4 to solution if no precipitate in Step 1.

→ If a white precipitate forms, $\text{Ba}(\text{NO}_3)_2$ is present.



Step 3: Add NaOH to solution if no precipitate in Step 1 and 2.

→ If a green precipitate forms, $\text{Fe}(\text{NO}_3)_2$ is present.



37. CHEMISTRY, M8 2020 HSC 22

Cation:

→ The cation can be identified via a flame test.

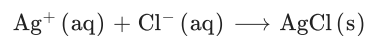
→ A pale green flame indicates barium, a brick red flame indicates calcium, and no flame colour observed indicates magnesium.

Anion:

→ To identify anion, add copper nitrate.

→ If a precipitate forms, it indicates the presence of hydroxide ions.

→ Next, add silver nitrate. If a white precipitate forms, this indicates chloride ions present. If no precipitate forms, it indicates acetate ions present.



Other answers

→ Identify anion by testing pH with universal indicator.

→ Interpret result: Neutral (Cl^- present), slightly basic (CH_3COO^- present), very basic (OH^- present).

♦ Mean mark 49%.

38. CHEMISTRY, M8 2021 HSC 30

→ The first test is unnecessary for the student to identify cations or anions.

→ All possible ions present will not form a precipitate with the NaCl reagent being added.

→ The second test is an appropriate method to identify the presence of cations or anions.

→ The addition of silver nitrate will form a precipitate with hydroxide ions but not acetate ions. Thus, the brown precipitate formed by the second test indicates the presence of hydroxide ions.

→ Additionally, it also eliminates the presence of magnesium cation, as magnesium hydroxide is insoluble.

→ The third test is an invalid method.

→ Sodium sulfate will form a precipitate with both barium and calcium ions, giving both a white precipitate. Thus, it is not possible to accurately distinguish between calcium and barium ions.

→ Instead, a flame test would be best to identify the cations, where a red flame will be found for calcium and a green flame would be found for barium.

♦ Mean mark 47%.

39. CHEMISTRY, M8 2015 HSC 29

a. Modification 1:

→ The BaCl_2 should be added slowly. This would help more of the sulfate ions come into contact with barium and form a precipitate.

♦ Mean mark (a) 49%.

Modification 2:

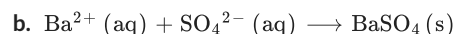
→ Barium sulfate is a very fine precipitate. By heating the mixture gently for some time, the BaSO_4 precipitate is able to flocculate into larger particles, which would be trapped by the filter.

Modification 3:

→ The pores of most filter paper are still too large to effectively capture the BaSO_4 precipitate. The experiment should use a small pore filter, like a sintered glass crucible.

Modification 4:

→ Multiple samples of the fertiliser should be analysed and the average value calculated to achieve more valid results. This would mitigate inaccuracies caused by unevenly distributed sulfate in the mixture.



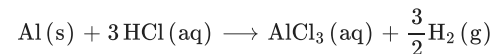
$$m_{\text{fertiliser}} = 2.00 \text{ g}, \quad m_{\text{precipitate}} = 2.23 \text{ g}$$

Mean mark (b) 54%.

$$m(\text{SO}_4^{2-}) = \frac{\text{MM}(\text{SO}_4^{2-})}{\text{MM}(\text{BaSO}_4)} \times 2.23 = \frac{96.07}{233.37} \times 2.23 = 0.918 \text{ mol}$$

$$\therefore \% \text{ of } (\text{SO}_4^{2-}) = \frac{0.918}{2.00} = 45.9 \%$$

40. CHEMISTRY, M8 2016 HSC 27



♦ Mean mark 48%.

→ The graph shows that all the aluminium has reacted when no more gas is being produced, at a volume of 0.150 L.

$$n(\text{H}_2) = \frac{0.150}{24.79} = 0.00605 \text{ mol}$$

$$n(\text{Al}) = \frac{2}{3} \times 0.00605 = 0.00403 \text{ mol}$$

$$\therefore m(\text{Al}) = 0.00403 \times 26.98 = 0.109 \text{ g}$$

41. CHEMISTRY, M8 2020 HSC 31

$$n(\text{SCN}^-) = c \times V = 0.0500 \times 0.02865 = 1.43 \times 10^{-3} \text{ mol}$$

♦♦ Mean mark 44%.

$$n(\text{Ag}^+)_{\text{excess}} = 1.43 \times 10^{-3} \text{ mol}$$

$$n(\text{Ag}^+)_{\text{added}} = 0.100 \times 0.02500 = 2.50 \times 10^{-3} \text{ mol}$$

$$\begin{aligned} n(\text{Ag}^+)_{\text{reacted}} &= n(\text{Ag}^+)_{\text{added}} - n(\text{Ag}^+)_{\text{excess}} \\ &= 2.50 \times 10^{-3} \text{ mol} - 1.43 \times 10^{-3} \text{ mol} \\ &= 1.07 \times 10^{-3} \text{ mol} \end{aligned}$$

$$n(\text{Cl}^-) = 1.07 \times 10^{-3} \text{ mol}$$

$$m(\text{Cl}^-) = n \times \text{MM} = 1.07 \times 10^{-3} \times 35.45 = 0.0378 \text{ g} = 37.8 \text{ mg}$$

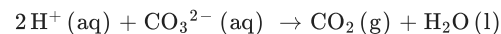
$$[\text{Cl}^-] = \frac{m}{V} = \frac{37.8 \text{ mg}}{0.100 \text{ L}} = 378 \text{ mg L}^{-1}$$

42. CHEMISTRY, M8 2023 HSC 30

Test 1: Add aqueous nitric acid

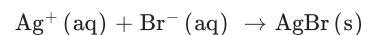
♦ Mean mark 53%.

→ Bubbles indicate carbonate present. Acid removes carbonate for further testing of sample



Test 2: Add silver nitrate solution

→ Creamy precipitate indicates bromide present



Answer could include:

→ Add excess silver nitrate solution – precipitate produced

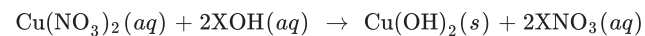
→ Add dilute nitric acid to the precipitate

- If bubbles are formed and a brown precipitate dissolves then carbonate was present
- If a creamy precipitate remains then bromide was present

43. CHEMISTRY, M8 2021 HSC 28

Since alkali metals are in group 1, they have a +1 charge.

♦ Mean mark 46%.



$$m(\text{Cu}(\text{OH})_2) = 4.61 \text{ g}$$

$$\begin{aligned} n(\text{Cu}(\text{OH})_2) &= \frac{m}{MM} \\ &= \frac{4.61}{97.566} \\ &= 0.04725 \text{ mol} \end{aligned}$$

$$2n(\text{OH}^-) = n(\text{Cu}(\text{OH})_2) = 0.09450 \text{ mol}$$

$$n(\text{XOH}^-) = 2n(\text{OH}^-) = 0.09450 \text{ mol}$$

$$n = \frac{m}{MM} \Rightarrow MM = \frac{m}{n}$$

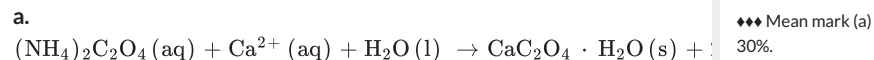
$$MM(\text{XOH}) = \frac{5.30}{0.0945} = 56.08 \text{ g mol}^{-1}$$

$$\begin{aligned} MM(\text{X}^+) &= MM(\text{XOH}) - MM(\text{OH}^-) \\ &= 56.08 - (16 + 1.008) \\ &= 39.077 \text{ g mol}^{-1} \end{aligned}$$

This is consistent with the molar mass of potassium (K) from the periodic table.

Therefore, the unknown alkali metal hydroxide is KOH (potassium hydroxide).

44. CHEMISTRY, M8 2013 VCE 2



b.

$$M(\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}) = 40.08 + 2(12.01) + 4(16) + 2(1.008) + 16 = 146.116 \text{ g mol}^{-1}$$
$$n(\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}) = \frac{0.523}{146.116} = 0.003579 \text{ mol}$$
$$n(\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}) = n(\text{Ca}^{2+}) = n(\text{CaCO}_3) = 0.003579 \text{ mol}$$
$$m(\text{CaCO}_3) = 0.003579 \times (40.08 + 12.01 + 3(16)) = 0.358 \text{ g}$$
$$\% \text{ Mass} = \frac{0.358}{0.412} \times 100 = 86.9\%$$

45. CHEMISTRY, M8 2016 VCE 6

a. Absorbance of 0.13 \rightarrow Cu^{2+} concentration of 1.1 g L^{-1} (see graph)

In 100 mL:

$$m(\text{Cu}^{2+}) = 1.1 \times 0.1 = 0.11 \text{ g}$$

$$\Rightarrow \% \text{ Cu}^{2+} = \frac{0.11}{0.198} \times 100 = 55.6\%$$

b. \rightarrow No, this would increase the concentration of the copper solution by a factor of 5.

\rightarrow The concentration of the solution and absorbance would be too high and outside the range of the calibration curve.

\rightarrow It can't be assumed that the calibration curve remains linear beyond the range of the known data.

c. Answers could include:

\rightarrow UV-vis spectroscopy, colorimetry, volumetric analysis, gravimetric analysis.

46. CHEMISTRY, M8 EQ-Bank 28

\rightarrow Atomic absorption spectroscopy (AAS) can be used to test if heating reduces water hardness.

\rightarrow It does this by calculating the concentrations of metal ions in solutions. AAS can calculate the concentration of Ca^{2+} in heated and non-heated samples of water and any difference in the relative concentrations of Ca^{2+} can be used to verify the suggestion.

\rightarrow It should be noted that a reduced concentration of Ca^{2+} indicates that the water hardness is reduced.

Methodology of testing

\rightarrow Prepare standard solutions with known concentrations of Ca^{2+} and measure their absorbance. Plot the concentrations against the absorbance of the standard solutions and draw a calibration curve (i.e. a line of best fit).

\rightarrow Measure the absorbance of a water sample before heating and another after heating. Using the absorbance and the calibration curve, calculate the concentration of Ca^{2+} in each sample and compare the concentrations between the heated and unheated samples.

\rightarrow The AAS should be calibrated, at which point the concentration of calcium ions can be calculated to an accuracy in the parts per million (ppm). To ensure accurate calibration of the AAS, the standard solutions need to be prepared precisely which will involve the accurate weighing of solids and the use of a pipette or a similar instrument to measure solution volumes.

\rightarrow Water used in the experiment should be de-ionised (normal drinking water has an abundance of Na^+ and Ca^{2+}).

\rightarrow The margin of experimental error decreases when sufficient calibration samples are used and the measurement of absorbance of these samples is repeated and averaged.

\rightarrow The reliability of results increases when many samples of heated and non-heated water are used to confirm that the concentrations of Ca^{2+} in the heated water samples are consistently lower than the concentrations of Ca^{2+} in the unheated water samples.

\rightarrow AAS can also be used to test the validity of the results. A hollow cathode lamp for calcium can direct light through the solution. This light has a specific wavelength that will only be absorbed by calcium ions. In this way, accurate measurements are made which can then be compared against the results and provide evidence of the validity of the original suggestion.

47. CHEMISTRY, M8 2019 HSC 29

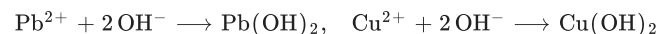
a. Recommended Treatment:

→ Calcium hydroxide is a slightly soluble compound, while copper(II) hydroxide and lead(II) hydroxide are very insoluble in water.

→ When these compounds are added to water, the metal ions tend to precipitate out of solution.

→ For example, the addition of solid calcium hydroxide to water produces calcium ions Ca^{2+} and hydroxide ions OH^- , which can then react with lead(II) ions (Pb^{2+}) and copper(II) ions Cu^{2+} to form precipitates of lead(II) hydroxide and copper(II) hydroxide, respectively.

→ These reactions are represented by the equations:



♦ Mean mark (a) 46%.

b. Atomic absorption spectroscopy (AAS):

→ Can be used for determining the concentration of metal ions in a sample by measuring the absorbance of light at specific wavelengths that are characteristic of each metal.

→ AAS uses light wavelengths that correspond to atomic absorption by the element of interest, and since each element has unique wavelengths that are absorbed, the concentration of that element can be selectively measured in the presence of other species.

→ As a result, AAS can be used to independently measure the concentrations of different metal ions, such as lead(II) ions and copper(II) ions in a sample containing both types.

♦♦ Mean mark (b) 32%.

c. Concentrations of ions:

Sample	$\text{Cu}^{2+} \times 10^{-5} \text{ mol L}^{-1}$	$\text{Pb}^{2+} \times 10^{-5} \text{ mol L}^{-1}$
Water (pre-treatment)	5.95	4.75
Water (post-treatment)	0.25	0.85

→ Concentrations of copper and lead have been significantly reduced.

♦ Mean mark (c) 53%.

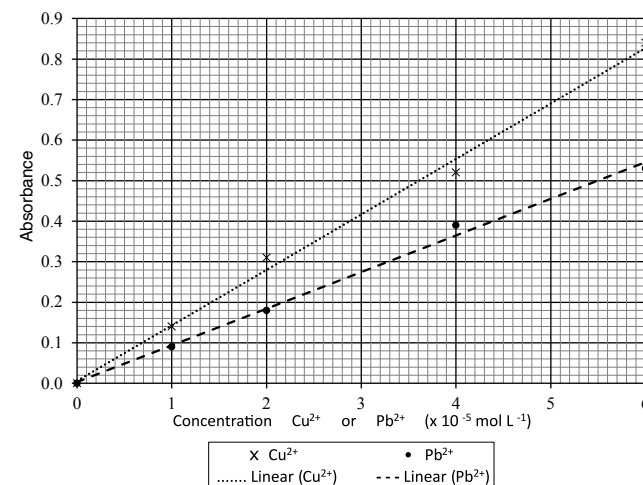
→ Convert concentrations to compare with standard:

$$\text{Cu}^{2+}: 5.95 \times 10^{-5} \times 63.55 \times 1000 = 3.78 \text{ mg L}^{-1}$$

$$0.25 \times 10^{-5} \times 63.55 \times 1000 = 0.16 \text{ mg L}^{-1}$$

$$\text{Pb}^{2+}: 4.75 \times 10^{-5} \times 207.2 \times 1000 = 9.84 \text{ mg L}^{-1}$$

$$0.85 \times 10^{-5} \times 207.2 \times 1000 = 1.76 \text{ mg L}^{-1}$$



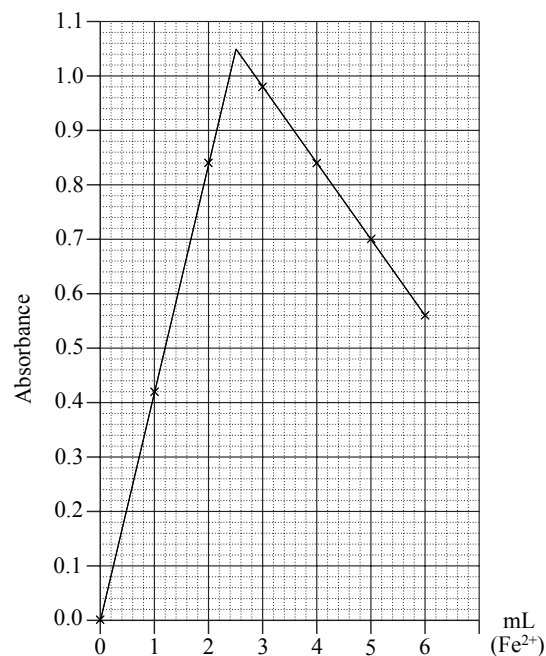
Conclusion:

→ The concentration of copper ions has been reduced to a level that is lower than the discharge limit ($0.16 < 1.0$) but the lead ion concentration has not ($1.76 > 1.0$).

→ The treatment has only been partially successful.

48. CHEMISTRY, M8 EQ-Bank 23

a.



b. Find values of a and b :

→ The graph shows that as the volume of compound X decreases between 10mL and 7.5mL, there is an increase in Fe^{2+} ions. This indicates an excess of Fe^{2+} ions limiting the products.

→ The absorbance reaches a maximum when the 2.5 mL of compound Fe^{2+} is added to 7.5 mL of compound X. Since the concentrations of the initial solutions are equal (given), equal volumes contain equal moles.

→ The ratio of volumes at peak absorbance = $2.5 : 7.5 = 1 : 3$ (i.e. the correct stoichiometric ratio).

→ Hence $a = 1$ and $b = 3$.

→ The curve then turns down sharply, indicating a reduction in Fe^{2+} .