S I

Student BOS Number

2019 Chemistry

TRIAL EXAMINATION

General Instructions

- Reading time – 5 minutes.
- Working time – 3 hours.
- Write using blue or black pen.
- Draw diagrams using pencil.
- Show all relevant working in questions involving calculations.
- NESA approved calculators may be used.

Total marks: 100

Section I – Multiple Choice and short response **84 marks**

- Attempt multiple choice questions 1 – 20.
- Allow about 35 minutes for this section.
- The multiple choice **answer sheet** is on p34 of the ***Section III*** **-** *Question 34* booklet

- Attempt short response questions 21 – 32
- Allow about 1 hour 55 minutes for this section.

Section II – Extended response question 33 **7 marks**

Section III – Extended response question 34 **9 marks**

- Attempt questions 33 and 34 in the booklets provided
- Allow about 30 minutes for these 2 sections

Section I – 20 marks

Attempt Questions 1-20

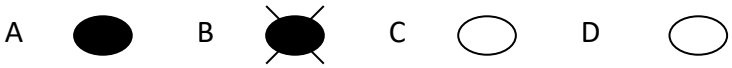
Allow about 35 minutes for this section

Use the multiple-choice answer sheet ***at the end of*** **Section III - Question 34** booklet.

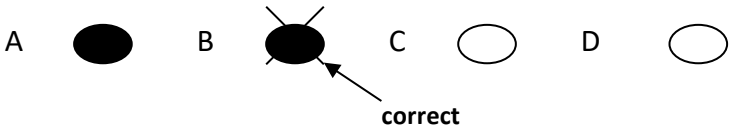
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.



If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



Section 1 – Multiple Choice

1. Indigenous Australians detoxified seeds of cycad plants, which contain the toxin cycasin, to allow the seeds to be eaten safely.

One method used in the detoxification process involved crushing the seeds to expose the inner kernels and then soaking the crushed seeds in water.

The property of the cycasin toxin upon which this method relies is:

(A) the higher density of the toxin compared to water.

(B) the reactivity of the toxin with water.

(C) the solubility of the toxin in water.

(D) the immiscible nature of the toxin in water.

2. Which one of the following is an example of an equilibrium system?

(A) Burning propane gas in a barbeque.

(B) A saturated solution of sodium chloride.

(C) Reacting magnesium with oxygen in a Bunsen flame.

(D) The production of glucose by photosynthesis.

3. Which of the following lists contains members of the same homologous series?

(A) C_2H_6, C_4H_{10}, C_6H_{14}

(B) C_2H_2, C_2H_4, C_2H_6

(C) C_2H_5Cl, C_2H_5OH, $C_2H_5NH_2$

(D) CH_3Cl, CH_2Cl_2, $CHCl_3$

4. Which of the following solutions, upon mixing will produce the solution with the highest temperature change?

(A) 50mL of 0.050M HNO_3 + 100mL of 0.4M NaOH

(B) 200mL of 0.05M CH_3COOH + 100mL of 0.01M NaOH

(C) 100mL of 0.1M H_2SO_4 + 50mL of 0.4M KOH

(D) 50mL of 0.2M HCl + 100mL of 0.025 $Ba(OH)_2$

5. Below is a table of reactions involving organic compounds

Reaction	Product
ethene + hydrogen chloride	1
ethanal + permanganate ion	2
ethanol + ethanoic acid	3
ethanoic acid + sodium carbonate	4

Which row of the table below correctly identifies a product from each reaction?

	Product 1	Product 2	Product 3	Product 4
(A)	chloroethane	ethanoic acid	ethanal	sodium ethanoate
(B)	chloroethene	ethanoic acid	ethyl ethanoate	carbon dioxide
(C)	chloroethane	ethanal	ethanoate ion	carbon dioxide
(D)	chloroethane	ethanoic acid	ethyl ethanoate	carbon dioxide

6. The indicator HIn/In^- is used in a titration between nitric acid and barium hydroxide solutions. The following equation represents how the indicator works.

$$\underset{\text{(green)}}{\mathbf{HIn}} \leftrightarrow \mathbf{H^+} + \underset{\text{(purple)}}{\mathbf{In^-}}$$

The indicator is added to 20mL of the barium hydroxide solution in a conical flask and the nitric acid is added via a burette until the endpoint is reached. The nitric acid and barium hydroxide solutions are of similar concentrations and the flask is swirled continuously as the acid is added.

Which one of the following statements describes the expected observations for the colour of the solution in the conical flask?

(A) It starts green and turns purple after adding approximately 10mL of HNO_3.

(B) It starts green and turns purple after adding approximately 40mL of HNO_3.

(C) It starts purple and turns green after adding approximately 10mL of HNO_3.

(D) It starts purple and turns green after adding approximately 40mL of HNO_3.

7. Ethanol is an important biofuel which releases energy when combusted. It can be produced from the fermentation of glucose, which in turn is produced by photosynthesis.

The following equations represent the reactions in this process.

Reaction 1: $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$

Reaction 2: $C_6H_{12}O_6(aq) \rightarrow 2CH_3CH_2OH(l) + 2CO_2(g)$

Reaction 3: $CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

Which statement correctly summarises the amount of $CO_2(g)$ in this process?

(A) More CO_2 is produced than consumed.

(B) More CO_2 is consumed than produced.

(C) The amount of CO_2 produced is the same as that consumed.

(D) The moles of CO_2 consumed is the same as the amount of ethanol produced.

8. When solid sodium ethanoate is dissolved in water, the following reaction takes place.

$CH_3COO^-(aq) + H_2O(l) \leftrightarrow CH_3COOH(aq) + OH^-$

Given the pK_a of ethanoic acid is 4.76 at 25°C, what is the pH of a 0.420M solution of sodium ethanoate?

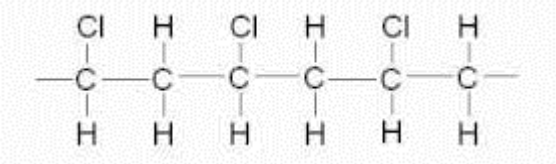
(A) 2.6

(B) 4.8

(C) 9.2

(D) 11.4

9. The structure shown below represents a fragment of a polymer made from two different monomers.



Which option is correct with respect to the synthesis of this polymer?

	Type of polymerization	**Reaction products**
(A)	Condensation	Polymer and water
(B)	Addition	Polymer only
(C)	Condensation	Polymer only
(D)	Addition	Polymer and water

10. The table gives heat of combustion kJ g^{-1} for a number of different fuels.

Fuel	Heat of combustion kJ g^{-1}
Butanol	30.8
Pentanol	36.5
Hexanol	41.2
Petrol (Octane)	47.8

The heat of combustion in kJ mol^{-1} for one of the fuels was calculated as 3218 kJ mol^{-1}. What was the fuel?

(A) Hexanol
(B) Octane
(C) Butanol
(D) Pentanol

11. Soaps and detergents are classified as emulsifiers because

(A) They reduce the hardness of water
(B) They reduce the surface tension of water
(C) They are polar
(D) They are biodegradable.

12. Four students analysed a sample of fertiliser to determine its percentage of sulfate.

Each student:

- Weighed an amount of fertiliser
- dissolved this amount in 100 mL of water;
- added aqueous barium nitrate;
- filtered, dried and weighed the barium sulfate precipitate.

Their results and calculations are shown in the table.

Student	Mass of fertiliser used (g)	Mass of $BaSO_4$ weighed (g)	Percentage of sulfate in fertiliser(%)
A	11.6	19.5	69.2
B	10.4	16.9	66.9
C	10.268	22.612	90.6
D	11.1	18.2	67.5

The percentage of sulfate calculated by Student *C* was significantly higher than that of the other students. Which is the most likely reason for this?

(A) Student *C* did not dry the sample for long enough.
(B) Student *C* added more $Ba(NO_3)_2$ solution than the other students.
(C) Student *C* used a balance capable of measuring weight to more decimal places.
(D) Student *C* waited longer than the other students for the $Ba(NO_3)_2$ to react completely with the sulfate.

13. Silver chloride dissolve in ammonia solution due to the formation of

(A) $[Ag(NH_3]_2)^+(aq)$
(B) $[Ag(NH_3)_2]^+(aq) + Cl^-(aq)$
(C) $[Ag(NH_3)_4](l)$
(D) $Ag(NH_2)_3(aq) + Cl^-(aq)$

14. Which of the following reactions would represent a dynamic equilibrium?

(A) Steel wool being burnt in a Bunsen Burner flame
(B) Granulated zinc being placed into a beaker with 100.00 mL of 1.0 $molL^{-1}$ HCl
(C) 100.00 mL of 1.0 $molL^{-1}$ HCl is reacted with 100.00 mL of 1.0 $molL^{-1}$ NaOH
(D) 5 drops of 0.1 $molL^{-1}$ Lead nitrate is reacted with 5 drops of 0.1 $molL^{-1}$ Silver chloride

15. Which of the following statements is **<u>incorrect</u>** about the collision theory of chemical reactions?

(A) It considers reacting molecules or atoms to be inflexible, rigid structures.
(B) The number of successful collisions determines the rate of reaction
(C) Product molecules are produced only when colliding reactant molecules or atoms possess the threshold energy.
(D) Reactant molecules or atoms should collide with sufficient threshold energy and correct orientation for the collision to successfully produce product molecules.

16. Consider the following equation:

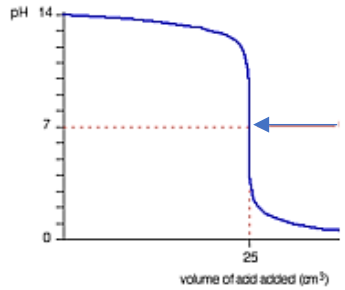
$2SO_2\,(g) + O_2\,(g) \rightarrow 2SO_3\,(g) \qquad \Delta H = -189.4kJ$

If the system was to experience a change in pressure and temperature select which changes in the table below would result in this system favouring the right.

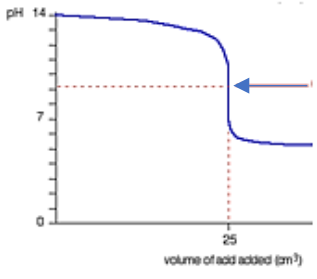
	Change in temperature	Change in pressure
(A	Decrease	Decrease
(B	Increase	Increase
(C	Decrease	Increase
(D	Increase	decrease

17. Titration curves are obtained when an acid and base are reacted with a pH probe inserted into one of the solutions. Refer to the graphs below, X and Y to answer which option a, b, c or d correctly identifies the acids and bases involved in this titration and also correctly identifies what the red arrow is indicating.

X



Y



	Graph X	Graph Y	The arrow
(A)	Strong base/Strong acid	Strong base/Strong acid	Equivalence point
(B)	Strong base/ Weak acid	Strong base/ Weak acid	Equivalence point
(C)	Weak base/Weak acid	Weak base/weak acid	Equivalence point
(D)	Strong base/Strong acid	Strong base/Weak acid	Equivalence point

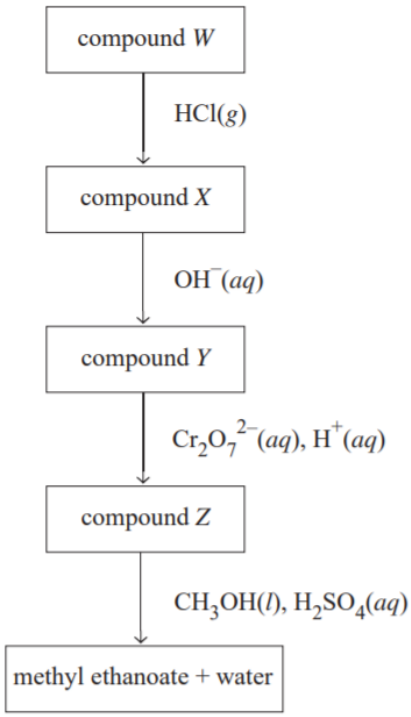
18. The pH of an alkaline solution is 8. Which of the following expressions could represent this solution?

(A) $[OH^-] = 10 - 8$
(B) $-\log_{10}[H^+] = 8$
(C) $\log_{10}[OH^-] = 8$
(D) $\log_{10}[H^+] = 8$

19. Which of the following pairs of compounds are **NOT** isomers?

(A) hexan-2-ol and 2,2-dimethylbutan-1-ol
(B) methyl ethanoate and propanoic acid
(C) butane and cyclobutane
(D) butan-2-one and 2-methylpropanal

20. The flow chart shows a sequence of reactions that result in the formation of methyl ethanoate.



Which row of the table correctly identifies the compounds labelled W, X, Y and Z?

	Compound W	*Compound X*	*Compound Y*	*Compound Z*
(A)	ethane	chloroethane	ethanol	methanoic acid
(B)	methane	chloromethane	methanol	methanoic acid
(C)	ethane	chloroethane	ethanol	ethanoic acid
(D)	ethene	chloroethane	ethanol	ethanoic acid

Section I - Short Response

Attempt Questions 21 – 32

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which questions you are answering.

Question 21 (3 marks)

Describe the relationship between the structure of soaps and their cleaning action. ***Include*** an appropriate diagram with your answer. **3**

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Question 22 (5 marks)

An equilibrium reaction involving 3 gases X, Y and Z has the following equilibrium constant expression:

$$K = \frac{[Y]^2}{[X]^3[Z]}$$

K = 3.2 for this system at 80°C.

(a) Write a balanced chemical equation to represent this equilibrium. **1**

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(b) The concentration of gases X, Y and Z were measured at a particular point in time (at 80°C) and found to be 0.45M, 0.21M and 0.25M respectively. **2**

Show that the system was not at equilibrium at this time.

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(c) Identify whether the forward or reverse reaction has the highest rate at this time. Justify your answer. **2**

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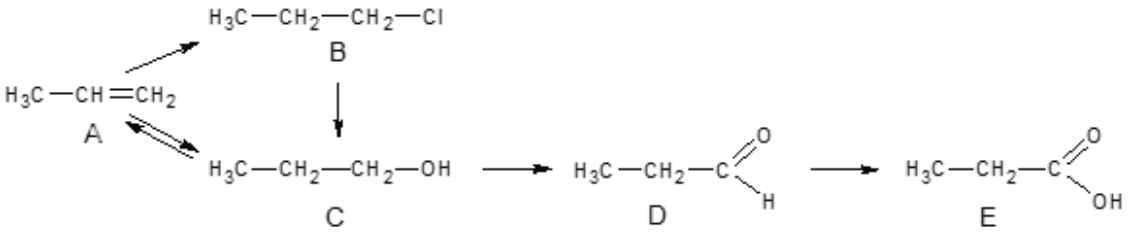
Question 23 (6 marks)

Consider the reactions shown below.



(a) Identify the systematic name of compound A. **1**

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(b) Draw the structural formula of compound C. **1**

(c) (i) Identify the systematic name of compound D. **1**

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(ii) Identify a reagent that will convert compound D into compound E. **1**

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(d) Write an equation using structural formulae, to show the reaction of compound E with methanol in the presence of concentrated H_2SO_4, and name the organic product. **2**

Question 24 (6 marks)

In order to demonstrate some solution chemistry, a science teacher prepares a number of practical tasks.

In the first task, she mixes 25 mL of 0.1 M $BaCl_2$ with 25 mL of 0.1 M $CuSO_4$.

(a) Write a balanced chemical equation to represent this reaction, including states. **1**

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(b) Write the net ionic equation for this reaction. **1**

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In another demonstration the teacher makes a saturated solution. She adds 1.52 g of $Cu(OH)_2$ (s) to 100.0 mL of water, and tells her students that the K_{sp} of $Cu(OH)_2$ is 2.2×10^{-20}.

(c) Write the dissociation equation of $Cu(OH)_2$ (s). **1**

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(d) Use the K_{sp} value to calculate the concentration of OH^- ions in this saturated solution of $Cu(OH)_2$. **3**

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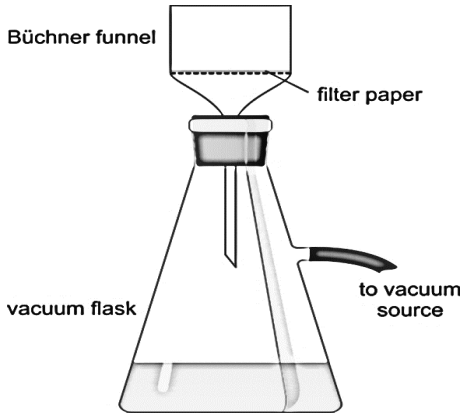
Question 25 (7 marks)

The following data may be helpful when answering this question.

Name	Formula	Solubility in water at 25°C (g/100g water)
Lead(II) ethanoate	$Pb(CH_3COO)_2$	55
Lead(II) iodide	PbI_2	0.076
Lead(II) nitrate	$Pb(NO_3)_2$	60
Potassium iodide	KI	142

Some brands of hair dye still contain lead (II) ions in an active ingredient, lead (II) ethanoate. In an investigation to estimate the amount of lead (II) ions in a particular brand of dye, 10.0g of the dye was measured. Enough solid potassium iodide is measured and dissolved in water to produce a 0.10M solution of potassium iodide.
An excess of the 0.1M potassium iodide was added to the dye sample. The precipitate that formed was filtered through pre-weighed filter paper, using the apparatus below.



The precipitate was washed in distilled water and the filter paper and precipitate heated gently.

The mass of the filter paper and precipitate was measured after several periods of gentle heating. The results are shown below.

Mass of filter paper (g)	0.298
Mass of filter paper + precipitate (g) *(after 1 period of heating)*	1.567
Mass of filter paper + precipitate (g) *(after 2 periods of heating)*	1.454
Mass of filter paper + precipitate (g) *(after 3 periods of heating)*	1.387
Mass of filter paper + precipitate (g) *(after 4 periods of heating)*	1.387

[Question continues on next page.]

a) Explain why potassium iodide is an appropriate reagent for this particular investigation. **2**

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b) Explain why the filter paper and precipitate was heated and weighed for several cycles, instead of just being heated and weighed once. **2**

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(c) Use the results of the investigation and the data provided to calculate the concentration of lead (II) ions (as a % w/w) in the dye sample. **3**

Include an appropriate balanced equation in your answer.

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Question 26 (3 marks)

In a beaker, enough sodium hydroxide of concentration 0.0288M is added to 10.5mL of 0.0355M sulfuric acid to make a total volume of 50.0mL. **3**

(a) Calculate the pH of the remaining mixture.

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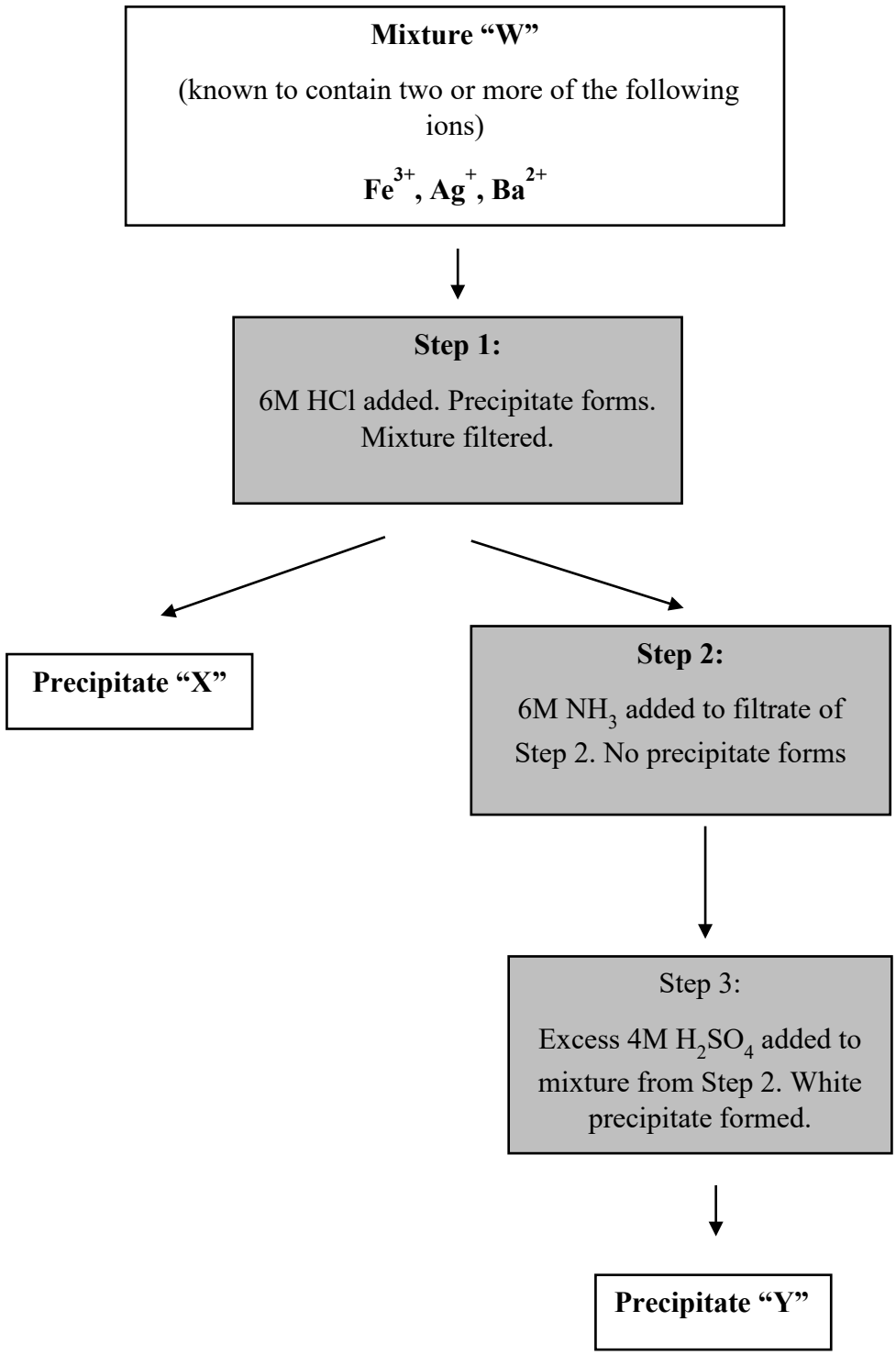
Question 27 (7 marks)

The flow chart below shows how a mixture of nitrate solutions (containing at least two of the cations shown) was analysed by a chemistry student.



[Question continues on next page.]

(a) Identify the cation present in precipitate "X". **1**

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(b) Explain why Step 1 must be carried out in order to make this scheme a valid way to analyse the unknown mixture. **2**

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(c) Dr Zhou was given a bottle with no label containing a mixture of three anions. **4**
The lab manager informed him that the bottle may contain acetate ions, sulfate ions and phosphate ions. The following reagents were available for testing:

- Concentrated sulphuric acid
- Dilute sulphuric acid
- Liquid ammonia
- Barium nitrate solution
- Iron(III) chloride solution
- Sintered glass filtration crucible
- Red litmus solution
- Blue litmus solution

Dr Zhou used **some** of the above reagents and confirmed the presence of *all three* anions given above.
Draw a flow chart that he may have used and justify the sequence of the tests done.

[Use the following page for your flowchart.]

Complete Question 27(c) answer here.

Question 28 (3 marks)

The boiling points of organic acids increase with increase in Molar Mass.

Name	BP (°C)	Name	BP(°C)	Name	BP(°C)
Propane	-42	Propan-1-ol	97	Propanoic acid	141
Butane	-1	Butan-1-ol	117	Butanoic acid	163
Pentane	36	Pentan-1-ol	139	Pentanoic acid	187
Hexane	68	Hexan-1-ol	159	Hexanoic acid	205

Predict and explain the difference in the boiling point of Alcohols and Organic acids. **3**

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Question 29 (8 marks)

a) A 0.1045 mol.L^{-1} solution of sodium hydroxide was used to determine the concentration of an unknown solution of acetic acid. The acetic acid was prepared by mixing 10.00mL vinegar with 90.00mL of distilled water. **4**

Using the results recorded below calculate the concentration of acetic acid in the bottle of Vinegar when 25.00 mL pipettes were used to deliver the vinegar into the conical flask.

Titre	Volume of Sodium Hydroxide (mL)
1	24.99
2	25.10
3	28.50
4	24.96

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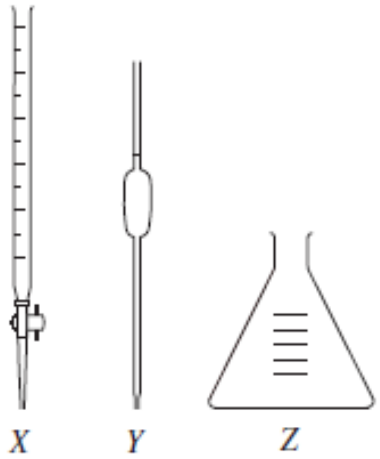
b) The diagram shows three pieces of glassware (*X*, *Y* and *Z*). **4**



Identify each piece of equipment and justify how each piece would be prepared and used for the titration above.

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Question 30 (4 marks)

Consider the reaction, $2NO_2(g) \leftrightarrow N_2O_4(g)$ $\Delta H = -57.20\ kJmol^{-1}$

a) Using the reaction, outline how activation energy (*Ea*) varies for the forward and the reverse reactions in equilibrium reactions. **2**

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b) How would increasing the temperature affect this reaction? Explain your answer. **2**

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Question 31 (4 marks)

Explain why refluxing is used to produce an ester. Include a labelled diagram in your answer.

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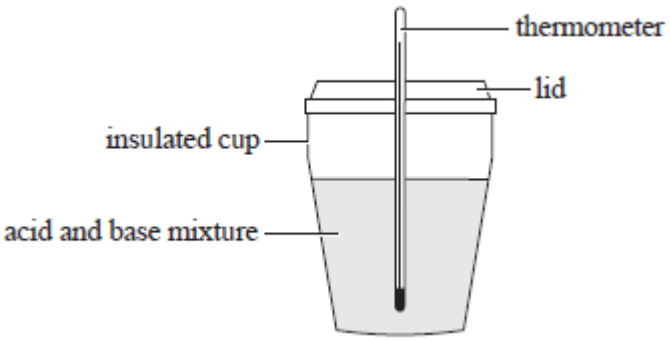
Question 32 (8 marks)

The diagram shows a coffee cup calorimeter used by a student to measure the enthalpy of neutralisation of an acid–base reaction.



120 mL of 0.500 mol L^{-1} sodium hydroxide was added to 60.0 mL of 0.500 mol L^{-1} sulfuric acid. Both solutions were at a temperature of 24.2°C. After mixing, the final temperature was 26.3°C.

(a) Calculate the enthalpy change per mole of water formed in this reaction. **3**

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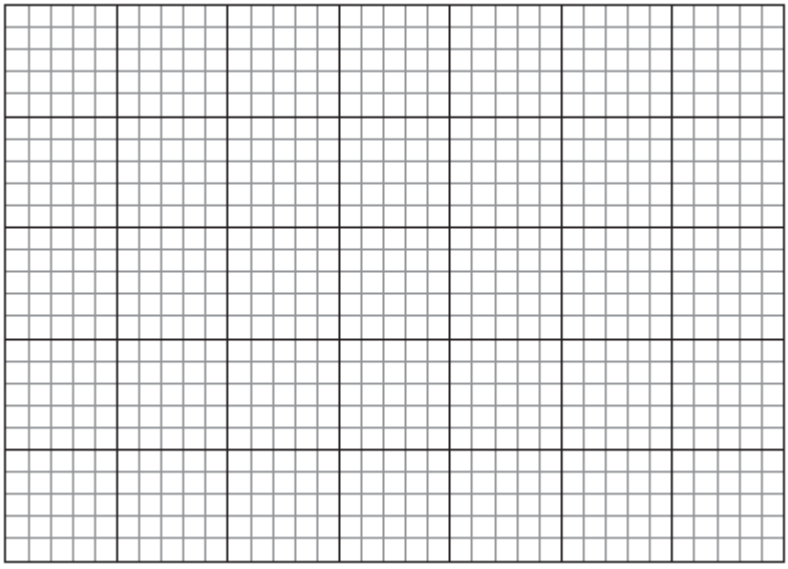
(b) The heat of combustion of a number of alcohols was measured. The results are shown in the table. **3**

Alcohol	*Enthalpy of combustion (kJ mol^{-1})*
methanol	–726
propan-1-ol	–2021
butan-1-ol	–2676
pentan-1-ol	–3331
hexan-1-ol	–3984

Using the data provided, construct a graph that shows the relationship between chain length (number of carbon atoms) and enthalpy of combustion for these alcohols.



(c) Using the graph constructed in part (b), predict the value of the enthalpy of combustion of ethanol in kJ per gram of ethanol. **2**

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S II

Student Number	
SECTION II - Q 33	/7

2019 Chemistry

TRIAL EXAMINATION

Section II – Question 33

- Only answer question 33 in this booklet.

Section II –Longer response question

Question 33 (7 marks)

(a) During your studies you explored how our definitions and models of acids and bases changed over time. How did you decide your references were valid and reliable? **2**

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(b) Using specific examples, explain the limitations of the acid base models provided by Arrhenius and Bronsted-Lowry theory and improvements in the above definitions. **5**

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Section II extra writing space.

Section II extra writing space.

S III

Student Number	
Multiple Choice	**/20**
SECTION III - Q 34	**/9**

2019 Chemistry

TRIAL EXAMINATION

Section III – Question 34

- Only answer question 34 and the Multiple Choice responses in this booklet.

NOTE: This section includes the Multiple Choice Answer sheet

Allow about 15 minutes for this section

Show all relevant working in questions involving calculations

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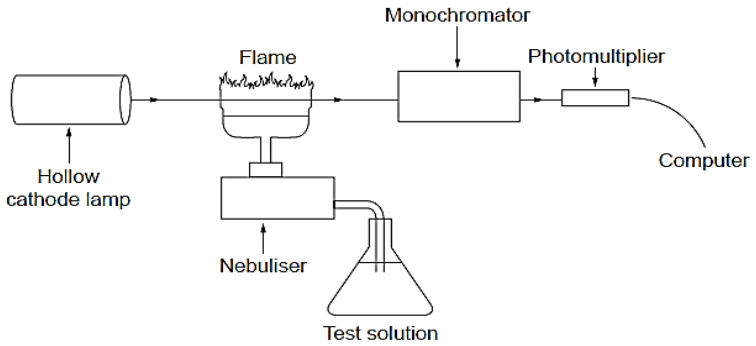
Question 34 (9 marks)

Yatin, a chemical analyst at Sydney University, suspected that his home's rainwater tank had an unusually high level of mercury ions as the water tasted awful. He therefore decided to perform analytical tests using an AAS to analyse some water samples from his home.

To do this,

- He accurately measured 250 ml of water samples early morning for four consecutive days.
- He evaporated each sample to about 50 ml, then pipetted the sample into a 100.00 mL volumetric flask and then diluted it with distilled water accurately to the mark.
- He repeated the above method for all his samples and tested each sample using AAS at the University.

Stimulus 1: A schematic diagram of the AAS used is given below.

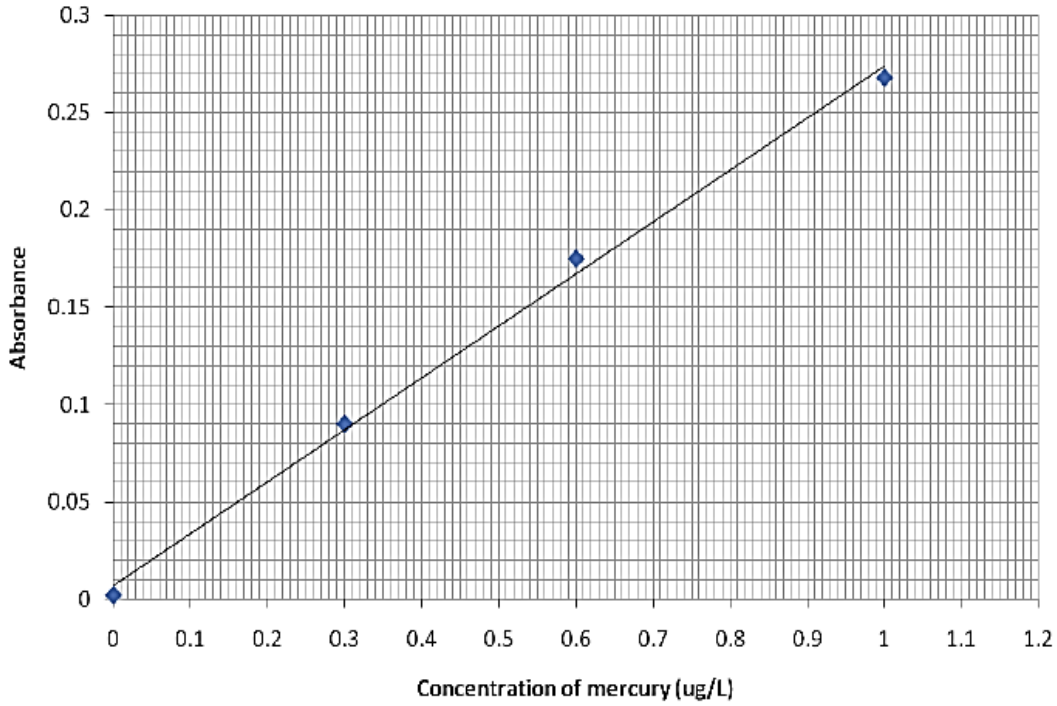


- He also prepared four standard mercury solutions. The complete result of the analysis are tabulated in the table and the table was then used to draw the graph in stimulus 3.

Stimulus 2: Recorded data

Mercury solution	*Concentration of Hg^{2+}* $(\mu g\ L^{-1})$	*Absorbance*
Standard 1	0.00	0.002
Standard 2	0.30	0.090
Standard 3	0.60	0.175
Standard 4	1.00	0.268
Water sample recorded an average absorbance of 0.140		
$1\ \mu g = 10^{-6}\ g$		

Stimulus 3: Graphical representation of collected data



The US Environmental Protection Agency, (EPA) has estimated a safe daily intake limit of mercury of 0.1 μg/kg of body mass. Yatin successfully performed further calculations to determine concentration of mercury in the water sample. He then justified the volume of water in litres that can be consumed by a 50 kg person daily without the adverse effect of mercury poisoning to his family.

Provide a detailed summary of Yatin's justification. Your response must include the following:

- the scientific principal of the function of AAS that Yain used to test his samples.
- Determining the concentration of mercury for his water sample using the calibration graph.
- Determining the volume of water in litres containing mercury that can be consumed by a 50 kg person daily using calculations to justify.

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Section III extra writing space.

Multiple Choice Answer Sheet

1.	A ○	B ○	C ○	D ○
2.	A ○	B ○	C ○	D ○
3.	A ○	B ○	C ○	D ○
4.	A ○	B ○	C ○	D ○
5.	A ○	B ○	C ○	D ○
6.	A ○	B ○	C ○	D ○
7.	A ○	B ○	C ○	D ○
8.	A ○	B ○	C ○	D ○
9.	A ○	B ○	C ○	D ○
10.	A ○	B ○	C ○	D ○
11.	A ○	B ○	C ○	D ○
12.	A ○	B ○	C ○	D ○
13	A ○	B ○	C ○	D ○
14.	A ○	B ○	C ○	D ○
15.	A ○	B ○	C ○	D ○
16.	A ○	B ○	C ○	D ○
17.	A ○	B ○	C ○	D ○
18.	A ○	B ○	C ○	D ○
19	A ○	B ○	C ○	D ○
20.	A ○	B ○	C ○	D ○

Section 1 – Multiple Choice

1. Indigenous Australians detoxified seeds of cycad plants, which contain the toxin cycasin, to allow the seeds to be eaten safely.

One method used in the detoxification process involved crushing the seeds to expose the inner kernels and then soaking the crushed seeds in water.

The property of the cycasin toxin upon which this method relies is:

(A) the higher density of the toxin compared to water.

(B) the reactivity of the toxin with water.

(C) the solubility of the toxin in water. ✓

(D) the immiscible nature of the toxin in water.

2. Which one of the following is an example of an equilibrium system?

(A) Burning propane gas in a barbeque.

(B) A saturated solution of sodium chloride.

(C) Reacting magnesium with oxygen in a Bunsen flame.

(D) The production of glucose by photosynthesis.

3. Which of the following lists contains members of the same homologous series?

(A) C_2H_6, C_4H_{10}, C_6H_{14} C_nH_{2n+2}

(B) C_2H_2, C_2H_4, C_2H_6

(C) C_2H_5Cl, C_2H_5OH, $C_2H_5NH_2$

(D) CH_3Cl, CH_2Cl_2, $CHCl_3$

4. Which of the following solutions, upon mixing will produce the solution with the highest temperature change?

all neutralisation exothermic

(A) 50mL of 0.050M HNO_3 + 100mL of 0.4M NaOH

(B) 200mL of 0.05M CH_3COOH + 100mL of 0.01M NaOH

(C) 100mL of 0.1M H_2SO_4 + 50mL of 0.4M KOH

(D) 50mL of 0.2M HCl + 100mL of 0.025 $Ba(OH)_2$

5. Below is a table of reactions involving organic compounds

Reaction	Product
ethene + hydrogen chloride	1
ethanal + permanganate ion	2
ethanol + ethanoic acid	3
ethanoic acid + sodium carbonate	4

Which row of the table below correctly identifies a product from each reaction? Use elimination

	Product 1	Product 2	Product 3	Product 4
(A)	chloroethane	ethanoic acid	ethanal	sodium ethanoate
(B)	chloroethene	ethanoic acid	ethyl ethanoate	carbon dioxide
(C)	chloroethane	ethanal	ethanoate ion	carbon dioxide
(D)	chloroethane ✓	ethanoic acid ✓	ethyl ethanoate ✓	carbon dioxide ✓

6. The indicator HIn/In⁻ is used in a titration between nitric acid and barium hydroxide solutions. The following equation represents how the indicator works.

$$\underset{\text{(green)}}{HIn} \leftrightarrow H^+ + \underset{\text{(purple)}}{In^-}$$

HNO_3 → $Ba(OH)_2$ + H^+ + In^- purple.

The indicator is added to 20mL of the barium hydroxide solution in a conical flask and the nitric acid is added via a burette until the endpoint is reached. The nitric acid and barium hydroxide solutions are of similar concentrations and the flask is swirled continuously as the acid is added.

Which one of the following statements describes the expected observations for the colour of the solution in the conical flask?

(A) It starts green and turns purple after adding approximately 10mL of HNO_3.

(B) It starts green and turns purple after adding approximately 40mL of HNO_3.

(C) It starts purple and turns green after adding approximately 10mL of HNO_3.

(D) It starts purple and turns green after adding approximately 40mL of HNO_3.

7. Ethanol is an important biofuel which releases energy when combusted. It can be produced from the fermentation of glucose, which in turn is produced by photosynthesis.

The following equations represent the reactions in this process.

Reaction 1: $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$

Reaction 2: $C_6H_{12}O_6(aq) \rightarrow 2CH_3CH_2OH(l) + 2CO_2(g)$

Reaction 3: $CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

Reaction of EtOH is imp

Which statement correctly summarises the amount of $CO_2(g)$ in this process?

(A) More CO_2 is produced than consumed.

(B) More CO_2 is consumed than produced.

(C) The amount of CO_2 produced is the same as that consumed.

(D) The moles of CO_2 consumed is the same as the amount of ethanol produced.

8. When solid sodium ethanoate is dissolved in water, the following reaction takes place.

$CH_3COO^-(aq) + H_2O(l) \leftrightarrow CH_3COOH(aq) + OH^-$ $\rightarrow 10^{-pKa}$

Given the pK_a of ethanoic acid is 4.76 at 25°C, what is the pH of a 0.420M solution of sodium ethanoate?

(A) 2.6

(B) 4.8

(C) 9.2

(D) 11.4

$pKa + pK_b = 14 = pK_w$ $\quad [H^+ \times OH^- = 10^{-14}]$

$pK_b = 14 - 4.76$

Step 1: $pK_b = 9.24 \Rightarrow K_b = 10^{-9.24} = 5.75 \times 10^{-10}$

Step 2:

	CH_3COO^-	+ $H_2O \rightleftharpoons$	CH_3COOH	+ OH^-	$\rightarrow K_b$
I	0.420	–	0	0	
C	$-x$	–	$+x$	$+x$	
E	$0.420 - x$		x	x	

$K_b = \frac{x^2}{0.420 - x} \simeq \frac{x^2}{0.420}$

$5.75 \times 10^{-10} = \frac{x^2}{0.420} \Rightarrow x = \sqrt{\quad}$

$x = 1.55 \times 10^{-5}$

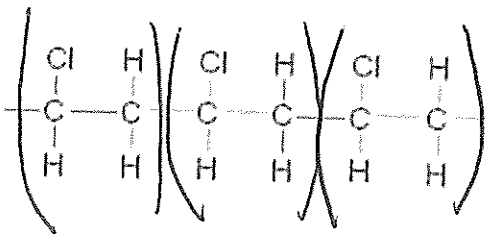
$pOH = -\log(\quad) = 4.809\,5$

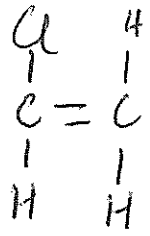
Step 3:

$pH = 14 - 4.809$

$pH = 9.191$

9. The structure shown below represents a fragment of a polymer made from two different monomers.





Which option is correct with respect to the synthesis of this polymer?

	Type of polymerization	Reaction products
(A)	Condensation	Polymer and water
(B)	Addition	Polymer only
(C)	Condensation	Polymer only
(D)	Addition	Polymer and water

10. The table gives heat of combustion kJ g^{-1} for a number of different fuels.

Fuel	Heat of combustion kJ g^{-1}
Butanol	30.8
Pentanol	36.5
Hexanol	41.2
Petrol (Octane)	47.8

The heat of combustion in kJ mol^{-1} for one of the fuels was calculated as 3218 kJ mol^{-1}. What was the fuel?

(A) Hexanol
(B) Octane
(C) Butanol
(D) Pentanol = 88.146 g

88.146g releases 3218KJ
1g " $\frac{3218}{88.146}$ KJ = 36.5KJ

11. Soaps and detergents are classified as emulsifiers because

(A) They reduce the hardness of water
(B) They reduce the surface tension of water
(C) They are polar
(D) They are biodegradable.

12. Four students analysed a sample of fertiliser to determine its percentage of sulfate.

Each student:

- Weighed an amount of fertiliser
- dissolved this amount in 100 mL of water;
- added aqueous barium nitrate;
- filtered, dried and weighed the barium sulfate precipitate.

Their results and calculations are shown in the table.

Student	Mass of fertiliser used (g)	Mass of $BaSO_4$ weighed (g)	Percentage of sulfate in fertiliser(%)
A	11.6	19.5	69.2
B	10.4	16.9	66.9
C	10.268	22.612	90.6
D	11.1	18.2	67.5

The percentage of sulfate calculated by Student *C* was significantly higher than that of the other students. Which is the most likely reason for this?

(A) Student *C* did not dry the sample for long enough.
(B) Student *C* added more $Ba(NO_3)_2$ solution than the other students.
(C) Student *C* used a balance capable of measuring weight to more decimal places.
(D) Student *C* waited longer than the other students for the $Ba(NO_3)_2$ to react completely with the sulfate.

13. Silver chloride dissolve in ammonia solution due to the formation of

(A) $[Ag(NH_3]_2)^+(aq)$ – incomplete
(B) $[Ag(NH_3)_2]^+(aq) + Cl^-(aq)$ → each stays dissolved by ion-dipole forces.
(C) $[Ag(NH_3)_4](l)$
(D) $Ag(NH_2)_3(aq) + Cl^-(aq)$

14. Which of the following reactions would represent a dynamic equilibrium?

(A) Steel wool being burnt in a Bunsen Burner flame
(B) Granulated zinc being placed into a beaker with 100.00 mL of 1.0 $molL^{-1}$ HCl
(C) 100.00 mL of 1.0 $molL^{-1}$ HCl is reacted with 100.00 mL of 1.0 $molL^{-1}$ NaOH
(D) 5 drops of 0.1 $molL^{-1}$ Lead nitrate is reacted with 5 drops of 0.1 $molL^{-1}$ Silver chloride

(complexation)

15. Which of the following statements is **incorrect** about the collision theory of chemical reactions?

Look for least correct

(A) It considers reacting molecules or atoms to be inflexible, rigid structures.

(B) The number of successful collisions determines the rate of reaction ✓

(C) Product molecules are produced only when colliding reactant molecules or atoms possess the threshold energy. Cross

(D) Reactant molecules or atoms should collide with sufficient threshold energy and correct orientation for the collision to successfully produce product molecules. ✓

16. Consider the following equation:

$2SO_2\,(g) + O_2\,(g) \rightarrow 2SO_3\,(g) \qquad \Delta H = -189.4kJ$ Not equilibrium

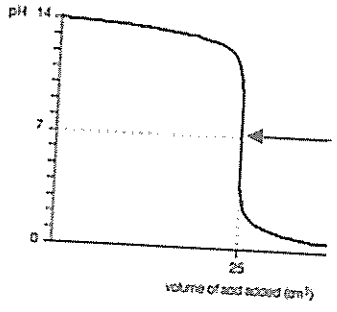
If the system was to experience a change in pressure and temperature select which changes in the table below would result in this system favouring the right.

	Change in temperature	Change in pressure
(A)	Decrease	Decrease
(B)	Increase more KE	Increase more collisions
(C)	Decrease	Increase
(D)	Increase	decrease

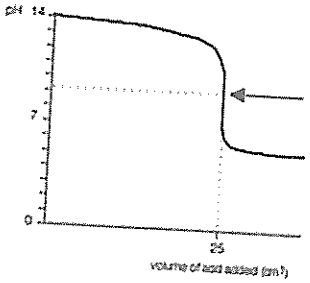
☹ check arrow first

17. Titration curves are obtained when an acid and base are reacted with a pH probe inserted into one of the solutions. Refer to the graphs below, X and Y to answer which option a, b, c or d correctly identifies the acids and bases involved in this titration and also correctly identifies what the red arrow is indicating.

X



Y



	Graph X	Graph Y	The arrow
(A)	Strong base/Strong acid	Strong base/Strong acid	Equivalence point
(B)	Strong base/ Weak acid	Strong base/ Weak acid	Equivalence point
(C)	Weak base/Weak acid	Weak base/weak acid	Equivalence point
(D)	Strong base/Strong acid	Strong base/Weak acid	Equivalence point

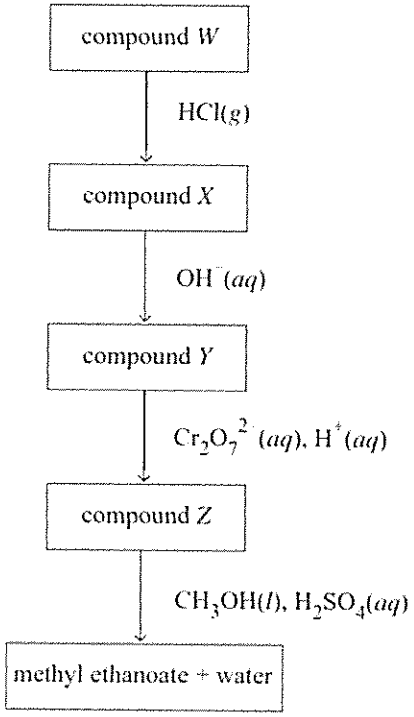
18. The pH of an alkaline solution is 8. Which of the following expressions could represent this solution?

(A) $[OH^-] = 10 - 8$
(B) $-\log_{10}[H^+] = 8$
(C) $\log_{10}[OH^-] = 8$
(D) $\log_{10}[H^+] = 8$

19. Which of the following pairs of compounds are **NOT** isomers?

(A) hexan-2-ol and 2,2-dimethylbutan-1-ol
(B) methyl ethanoate and propanoic acid
(C) butane and cyclobutane
(D) butan-2-one and 2-methylpropanal

20. The flow chart shows a sequence of reactions that result in the formation of methyl ethanoate.



Which row of the table correctly identifies the compounds labelled W, X, Y and Z?

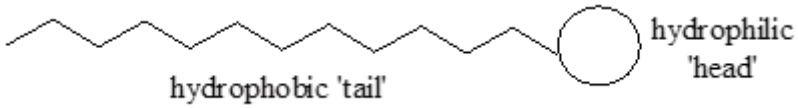
	Compound W	*Compound X*	*Compound Y*	*Compound Z*
(A)	ethane	chloroethane	ethanol	methanoic acid
(B)	methane	chloromethane	methanol	methanoic acid
(C)	ethane	chloroethane	ethanol	ethanoic acid
(D)	ethene	chloroethane	ethanol	ethanoic acid

TRIAL MG for q 21, 22, 23 TK

Q 21

Marking Criteria	Marks
• Describes the structure of soap and relates this to its cleaning action using appropriate scientific language. • Must explain that the **tail is NON POLAR** and **dissolves** in the oil /grease and the **head is POLAR** and so **dissolves** in the water.- thus suspends the oil in the water **via micelles- mentions agitation.** • Clear and logical • Draws an appropriate labelled diagram - micelle or soap particle	**3**
• Outlines the structure of soap and relates this to its cleaning action. • Draws an appropriate diagram	**2**
• Response contains one correct, relevant statement.	**1**

Soaps are long-chain species with a non-polar, hydrophobic 'tail' and a hydrophilic 'head'. For soaps the hydrophilic 'head' is the carboxylate ion,. The structure of these species can be represented as:



Oil and water are not miscible. When soap or detergent is added to a mixture of oil and water the hydrophobic end dissolves in the oil droplets. The hydrophilic end dissolves in the water. When the mixture is agitated a spherical particle called a micelle is formed in which the oil droplet is surrounded by soap particles, which are in turn surrounded by water molecules. In this way the soap acts as an emulsifying agent and an emulsion of oil and water is formed. This allows the oil to be washed away and accounts for the cleaning action of soaps and detergents.

Q22a

Marking Criteria
• Writes the correct balanced chemical equation. Includes states

$3X(g) + Z(g) \leftrightarrows 2Y(g$

22.b.

Marking Criteria	Marks
• Correctly shows that the system is not at equilibrium by calculating Q and comparing it with K.	**2**
• Correctly calculates Q.	**1**

$Q = 0.21^2/(0.45^3 \times 0.25) = 1.94.$

Because Q does not equal K the system is not at equilibrium.

Marking Criteria	Marks
• Correctly identifies that the forward reaction has the fastest rate at this time with the correct justification. • Must mention that the systems **shift to R to increase concentration of the product Y.**	**2**
• Correctly identifies that the rate of the forward reaction is fastest at this time OR that the equilibrium position is shifting to the right.	**1**

Q < K and as a result the system is shifting to the right in order to **increase [Y]** and increase the value of Q until it equals K. This means that the forward reaction has the fastest rate at this time.

Cannot say that the concentration of the products is less than the concentration of the reactants! Not comparing the concentration of reactants to products- Q is smaller than K therefore need to push eq to R to increase concentration of of products since [P]/[R]

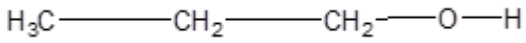
Q23

Marking Criteria	Marks
• Identifies propene.	**1**

propene

23.b.

Marking Criteria	Marks
• Correctly draws the structural formula for 1-propanol.	**1**



23.c.i.

Marking Criteria	Marks
• Identifies the name as propanal	**1**

propanal

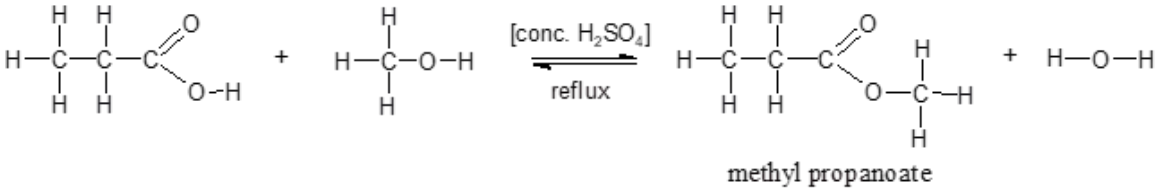
23.c.ii.

Marking Criteria	Marks
• Identifies acidified dichromate (or potassium/sodium dichromate)	**1**

acidified dichromate solution.

23.d.

Marking Criteria	Marks
• Writes the correct esterification equation using structural formulae and correctly names the organic product. Must have equilibrium arrows and water is structural.	**2**
• Response contains one correct feature.	**1**



methyl propanoate

2019 TRIAL HSC MARKING CRITERIA Q24 – 28 [CY]

24.a.

Marking Criteria	Marks
• Writes the correct balanced chemical equation including states.	**1**

$BaCl_2(aq) + CuSO_4(aq) \rightarrow BaSO_4(\mathbf{s}) + CuCl_2(aq)$

Note: This is a precipitation reaction. An equilibrium sign is incorrect

24.b.

Marking Criteria	Marks
• Writes the correct net ionic equation.	**1**

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

Note: Net ionic equations are written with a single direction arrow amd only include the *reacting* ions.

24c.

Marking Criteria	Marks
• Writes the correct balanced chemical equation including states.	**1**

$Cu(OH)_2(s) \leftrightarrow Cu^{2+}(aq) + 2OH^-(aq)$

24d.

Marking Criteria	Marks
• Correctly calculates $[OH^-]$, includes an equation for K_{sp}.	**3**
• Response contains one error.	**2**
• Response contains one correct step, or • Correct K_{sp} equation	**1**

Answer:

$Cu(OH)_2(s) \leftrightarrow Cu^{2+}(aq) + 2OH^-(aq)$.

If $[Cu^{2+}] = x$ then $[OH^-] = 2x$.

R	$Cu(OH)_2(s) \leftrightarrow$	$Cu^{2+}(aq)$	$2OH^-(aq)$
I	In a *saturated* solution $[Cu(OH)_2] = 1$	0	0
C	1	x	2x
E	1	x	2x

$K_{sp} = [OH^-]^2[Cu^{2+}] = (2x)^2 . x = 4x^3$ (1 mark)

Therefore solve for x: $2.2 \times 10^{-20} = 4x^3$

$x^3 = 5.5 \times 10^{-21}$ M

$x = 1.77 \times 10^{-7}$ M (1 mark)

Therefore $[OH^-] = 2 \times 1.77 \times 10^{-7} = 3.5 \times 10^{-7}$ M. (must include units - 1 mark)

Notes: Many students confused the Ka calculation. In Ksp the saturated precipitate =1.
Many students forgot that $[OH^-] = \mathbf{2}x$
Significant figures were not counted in this question, BUT always consider them.

25a.

Marking Criteria	Marks
• Explains *two* properties of KI that make it useful as a reagent to determine the concentration of the lead in the sample.	**2**
• Explains *one* property of KI that make it useful as a reagent to determine the concentration of the lead in the sample.	**1**

Sample answer:

Potassium iodide is a useful reagent in this analysis because it has a high solubility in water (1 mark), and so is able to be made up into an aqueous solution to add to the test solution. Lead(II) iodide is insoluble (1 mark) and hence addition of the KI solution will result in formation of a lead iodide precipitate, which can be filtered off and weighed.

Note: Use the stimulus material provided.

Potassium not precipitating with acetate ion as they are always soluble was also accepted.

Providing the reason that lead iodide is yellow was insufficient for a mark as colour was not part of the stimulus material.

25b.

Marking Criteria	Marks
• Explains why the filter paper and precipitate are heated and weighed over several cycles.	**2**
• Identifies that heating dries out the precipitate and removes water.	**1**

Heating and weighing the filter paper over several cycles allows you to heat and dry to constant mass (1 mark), ensuring all of the water is removed (1 mark) from the precipitate, so the mass remaining is that of pure lead(II) iodide.

Note: Students confused accuracy and reliability. The *accuracy* of results is about precision ie a constant mass. Reliability, in this instance, would be repeating the experiment several times to form a precipitate.

25c.

Marking Criteria	Marks
• Calculates the concentration of lead in the dye as a % (w/w), including an appropriate balanced equation.	**3**
• Calculates the concentration of lead in the dye as a % (w/w) **OR** • Calculates the moles of PbI2 in the precipitate AND includes an appropriate balanced equation. **OR** • One error in the method.	**2**
• Completes ONE correct step in the calculation **OR** • Includes an appropriate balanced equation.	**1**

Reaction: Pb^{2+} (aq) + $2I^-$ (aq) → PbI_2 (s) (1 mark)

$m(PbI_2)$ = 1.387 – **0.298** = 1.089 g (*Common error* – students forgot to deduct the mass of the filter paper)

$n(PbI_2)$ = m/MM = 1.089/461.0 = 0.00236226 moles (1 mark)

Thus $n(Pb^{2+})$ = 0.00236226 moles (1:1 ratio)

$m(Pb^{2+})$ = n x MM = 0.00236226 x 207.2 = 0.48946 g (**in 10g sample**)

Therefore, %(w/w) (Pb^{2+}) = (0.48946g/10g) x 100 = 4.89 % (1 mark)

***Note*:** Other calculations were also possible to achieve the correct answer

26

Marking Criteria	Marks
• Calculates the pH of the final mixture and includes balanced equation, moles of reactant in XS, equation for pOH and pH	**3**
• Calculates the pH of the final mixture but makes one error OR • Finds correct [OH].	**2**
• Completes one step in the calculation correctly.	**1**

$2NaOH\ (aq) + H_2SO_4\ (aq) \rightarrow Na_2SO_4\ (aq) + 2H_2O$ (1 mark)

$n(NaOH) = cV = 0.0288 \times \mathbf{0.0395} = 0.0011376$ (1 mark)
$n(H_2SO_4) = cV = 0.0355 \times \mathbf{0.0105} = 0.00037275$

As per the stoichometric ratio: H_2SO_4: 0.0037275 /1 = 0.00037275 NaOH: 0.0011376/2 = 0.0005688
Therefore limiting reagent = $n(H_2SO_4) < n(NaOH)$

NaOH is in excess.
$NaOH_{\ reacting} = 0.00037275 \times \mathbf{2} = 0.0007455$ } Most errors occurred here
$n(NaOH)_{\ remaining} = 0.0011376 - 0.0007455 = 0.0003921$ mol

Total volume = 39.5mL + 10.5 mL = 50 mL = 0.050L

$[OH^-]_{\ final} = n/V = 0.0003921/\mathbf{0.05} = 0.007842M$ (1 mark)

$pOH = -\log [OH^-]$
$pOH = -\log 0.007842 = -2.106$ (1 mark)

Because, pH + pOH =14 then pH = 14 - 2.106 = 11.9 (1 mark)

Note: Must show explanation and working to get marks – cannot see where an error occurs

27a

Marking Criteria	Marks
• Identifies the cation in precipitate "X".	**1**

Ag^+
Note: AgCl was not accepted because it isn't a cation.

27b.

Marking Criteria	Marks
• Explains why Step 1 *must* be carried out in order to make this scheme a valid way to analyse the unknown mixture.	**2**
• Identifies that only Ag^+ forms a precipitate with the Cl^- **OR** that two ions could precipitate with the OH^-.	**1**

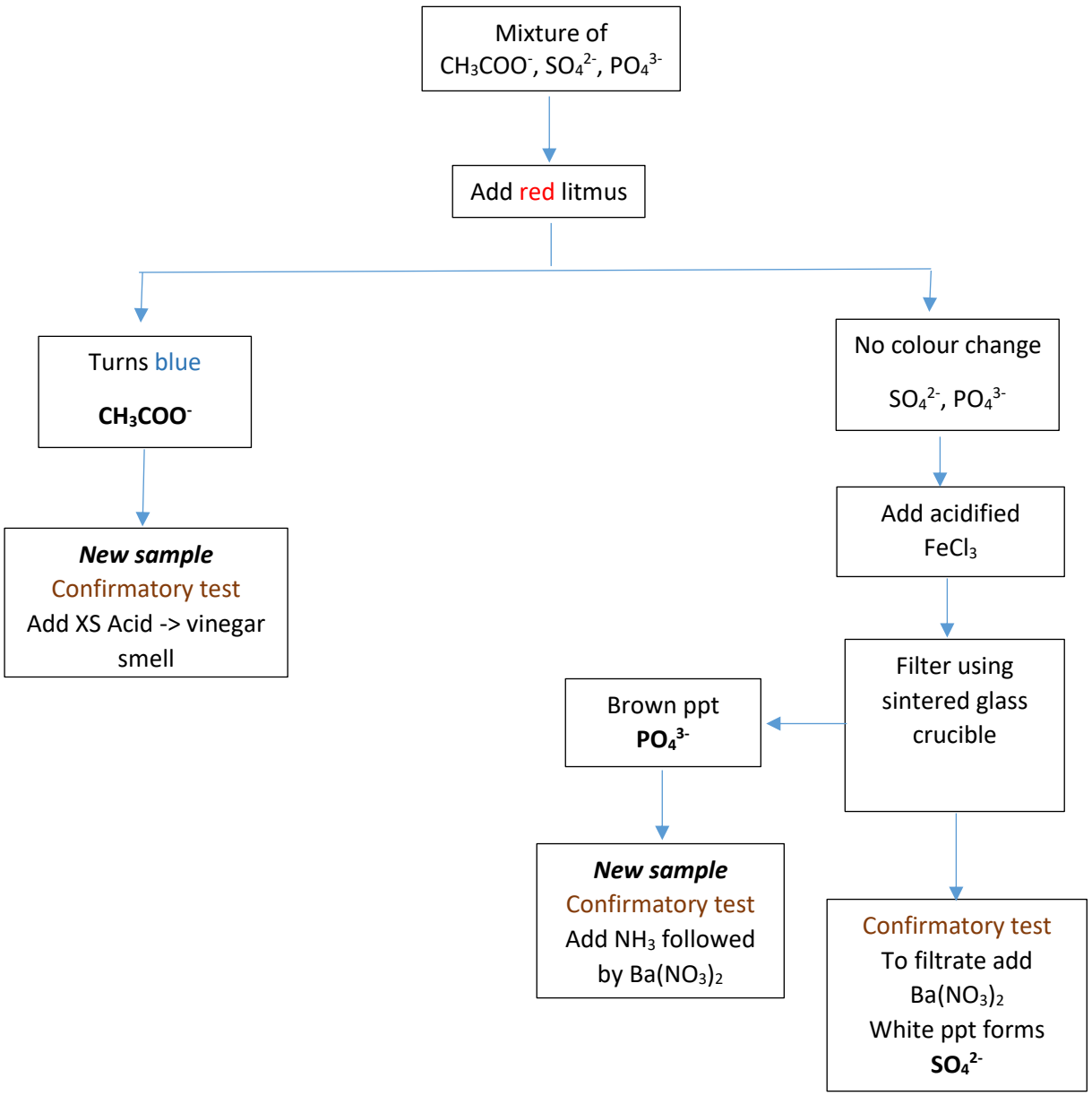
The mixture contains at least 2 cations, thus one cation present may ***mask the presence*** of the other or interfere with the next test. Ag^+ is the only cation that forms a precipitate with Cl^- (1 mark) so the first step is to add the Cl^- to remove only the Ag^+, so that the Ag^+ does not remain to form precipitates with OH^- or SO_4^{2-} (1 mark). If OH^- was added first, two precipitates could form (AgOH and $Fe(OH)_3$) similarly, if sulfate were added first (barium and silver would both precipitate). For these reasons, the Cl^- should be added before the OH^-.
Notes: Confusion over the role of and acid. In this case HCl is adding chloride ions and H_2SO_4 is adding sulfate ions

27c

Marking Criteria	Marks
• Draw a well formatted flow chart to identify ALL the anions listed and **justifies** the sequence of the tests done. • Includes at least ONE confirmatory tests.	**4**
• Draw a well formatted flow chart to identify ALL the anions listed and justifies the sequence of the tests done. **OR** • Three good tests indicated but one error in the flow chart	**3**
• Draws a flow chart that identifies two of the anions listed	**2**
• Draws a flow chart that could be used to identify one the anions listed	**1**

Notes:

- This question was difficult and very poorly done.
- Flow charts should have arrows, they must be logical and show processes
- No marks deducted for using the blue to red instead of red to blue litmus test to identify acetate ion (due to error in hand outs).
- H_2SO_4 was accepted for acidification as HNO_3 was not an option.
- Barium ions will precipitate with both sulfate and phosphate ion in acidic conditions. Adding XS NH_3 will dissolve the barium phosphate only.



Q 28

Marking criteria	Marks
• Predicts that acids have higher boiling point than alcohols due to the difference in functional group. • Explains the variation in boiling points between carboxylic acid and alcohols in terms of the strength of the intra-molecular forces • Specifies the following bond types (dipole, hydrogen or dimer formation)	3
Predicts that acids have higher boiling points Outlines the variation	2
Identifies acids have higher boiling points OR identifies the reason for variation	1

Sample answer:

The BP of both alcohols and carboxylic acids increase as the molar mass increases. This is due to the increasing dispersion forces that require greater amounts of energy to break the bonds. Acids have a higher BP than alcohols because they contain a carbonyl and a hydroxyl group (alcohols only have a single hydroxyl group). The hydroxyl group forms hydrogen bonds and the dipole that forms on the carbonyl group provides another hydrogen bonding site. In fact, carboxylic acid molecules can form dimers that very stable and require more energy to separate the molecules.

Notes:

- Use diagrams to chow intermolecular bonding
- The question only asked for a comparison of boiling point between carboxylic acids and alcohols. Alkanes were not relevant.

Q29

a) A 0.1045 mol.L^{-1} solution of sodium hydroxide was used to determine the concentration of an unknown solution of acetic acid. The acetic acid was prepared by mixing 10.00mL vinegar with 90.00mL of distilled water.

Using the results recorded below calculate the concentration of acetic acid in the bottle of Vinegar when 25.00 mL pipettes were used to deliver the vinegar into the conical flask.

Titre	Volume of Sodium Hydroxide (mL)
1	24.99
2	25.10
3	28.50
4	24.96

Marks	
Writes fully balanced chemical equation with states Averages titre but ignores #3 = 0.0250167L Calculates moles of sodium hydroxide and relates to moles of acetic acid = 2.6142×10^{-3} Calculates concentration of acetic acid used or uses C1V1=C2V2 correctly Dilutes concentration by 10 due to 1 in 10 dilution Therefore Correctly calculates concentration of acetic acid as 1.046M 4 sig fig	4
Calculates concentration of vinegar correctly as 0.104569M but incorrect dilution step to determine concentration of acetic acid	3
Missing relevant steps and incorrect answer	2
1 correct step	1

***Note: Common error**: Dividing number of moles of vinegar by 0.1 L. You must find the concentration of vinegar in the conical flask first. That concentration is the same as the vinegar in the bottle (100 ml).*
Then perform the dilution. Original is 10 times more concentrated.
***Other errors**: unit conversion, missing important calculation steps, no sig fig in final answer.*

Q29b

Identify X as burette Y as pipette Z as conical flask	
Correct rinsing **TECHNIQUE AND SOLUTION AND JUSTIFICATION** for ***burette***: Burette rinsed with **distilled water** twice/thrice to get rid of all contaminants and other impurities, then rinsed by swirling twice with **NaOH** only so that all parts of the burrette is in touch with **titrant** only.	4
Correct rinsing **TECHNIQUE AND SOLUTION AND JUSTIFICATION** for ***pipette:*** Any traces of reagents other than analyte will change the concentration of the analyte. So the pipette must be rinsed thoroughly with dH_2O first then several times with the **analyte vinegar** ensuring **no water traces** are there and the rinsings are discarded to get rid of all contaminants and other impurities, then filled up to the mark with vinegar to be analysed.	
Correct rinsing **TECHNIQUE AND SOLUTION AND JUSTIFICATION** for conical flask***:*** Conical flask rinsed thoroughly with distilled water only and the rinsings are discarded to get rid of all contaminants and other impurities, then the conical flask is left wet before adding analyte. During titration, dH_2O is added to conical flask to wash down titre into the flask therefore it can be left wet. It does not change the number of moles of analyte added to the flask at the start.	
Correctly identifies each equipment AND Correct rinsing techniques **AND/OR** all detailed RINSING SOLUTIONS AND/OR Some Justification provided for any	3
Correctly identifies each equipment AND Some incorrect rinsing techniques OR GENERAL RINSINGS described AND No justification provided for any	2
Identify each piece of equipment Or Identifies a piece of equipment and justifies how it is used OR Some correct relevant information	1

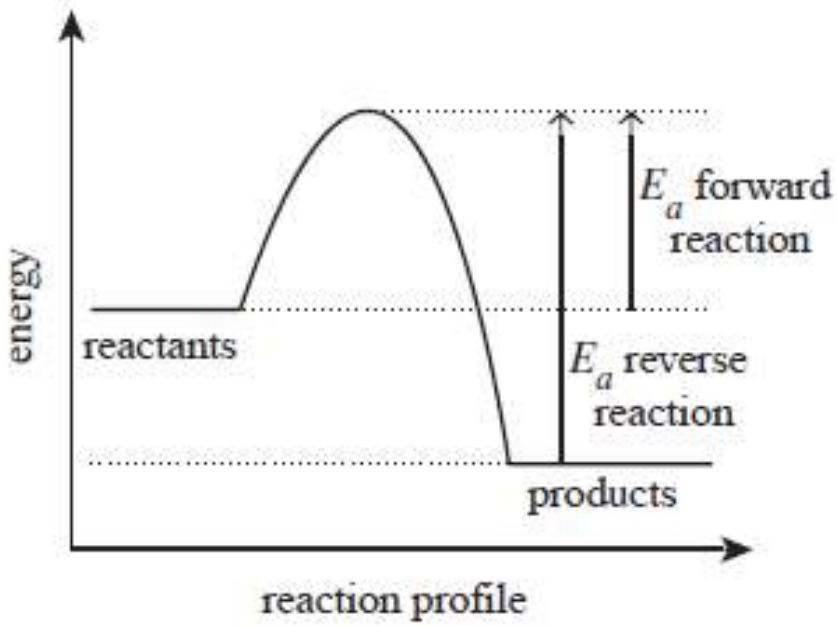
Question 30 (4 marks)

Consider the reaction, $2NO_2(g) \leftrightarrow N_2O_4(g)$ $\Delta H = -57.20\ kJmol^{-1}$

a) Using the reaction, outline how activation energy (*Ea*) varies for the forward and the reverse reactions in equilibrium reactions. **2**

• Compares E_a for forward reaction wrt reverse reaction (MAY USE A GRAPH) AND • Identifies forward reaction as exothermic	2
Compares E_a for forward reaction wrt reverse reaction **OR** • Identifies forward reaction as exothermic	1

For an **exothermic reaction**, the activation energy of **the forward reaction must be less than the activation energy** of the reverse reaction.
This is an **exothermic reaction**;
hence the ***Ea*** **for the forward reaction (forming dinitrogen tetroxide**) is less than the *Ea* for the **reverse reaction (forming nitrogen dioxide).**



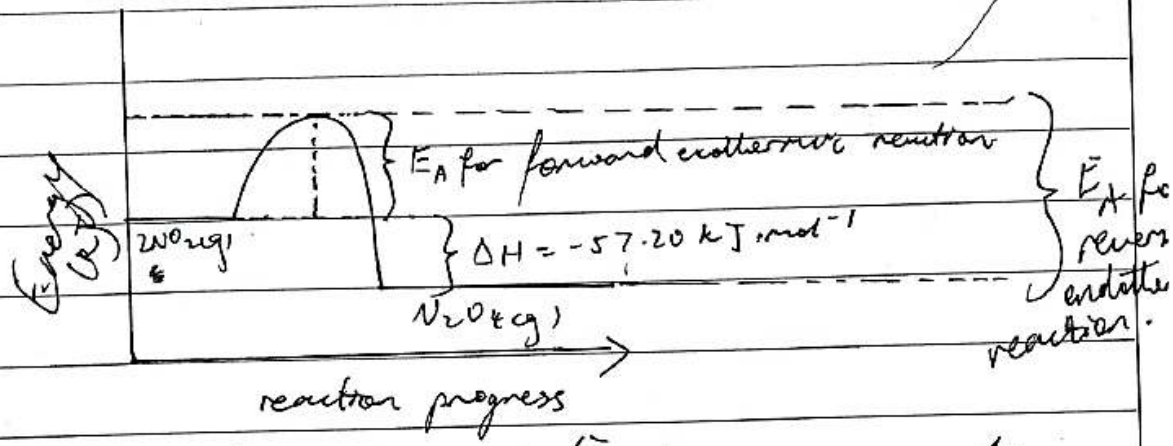
Note: A diagram is not required for full marks. It has been included for clarification.

Student sample attached below

Andrew Zhou's graph

Start here.

The forward reaction is exothermic because $\Delta H < 0$, at $-57.20\ kJ\ mol^{-1}$. As to the reaction profile of this reaction:



E_A for forward reaction < E_A for reverse reaction as the forward reaction is exothermic, while the reverse reaction is endothermic.

b) How would increasing the temperature affect this reaction? Explain your answer. **2**

Marking criteria	**Mark**
Describes how increasing the temperature would affect the reaction. AND • Provides correct explanation.	2
Describes how increasing the temperature would affect the reaction. OR • Provides correct explanation.	1

Effect- Increasing the temperature would drive the position of equilibrium **to the left (formation of nitrogen dioxide**).

Reason - Le Châtelier's principle states that the addition of heat to reaction will **favour the endothermic** direction of a reaction in order to **minimise (imposed change) the increase in heat content of the system** when the temperature is increased.

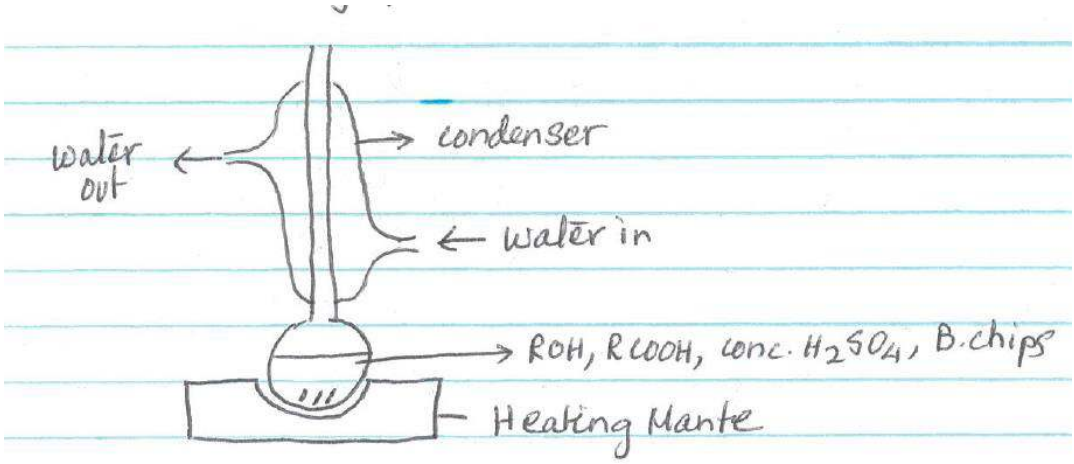
Question 31 (4 marks)

Explain why **refluxing** is used to produce an ester. Include a labelled diagram in your answer.

Marking Criteria	Marks
Explains correctly two main reasons for refluxing (Answer in terms of RATE & SAFETY) AND Includes a correctly labelled diagram	4
Describes one or two reason for refluxing AND Includes a correctly labelled diagram OR **ONE ERROR IN DIAGRAM**	3
Outlines a reason for refluxing AND Includes a substantially correct diagram	2
States a reason for refluxing AND Includes a diagram recognisable as reflux apparatus	1

Explains refluxing:

1. High Temperature allows: **faster rate** possible due to more **K.E in the system.**
2. Safety - Prevents **loss of volatile reagents** increasing yield and **safety increased by condensing volatile reagents** back into the flask.
3. Open top – no pressure build up



Note:

Diagram should be large

No gaps between refluxing condenser and reaction vessel

No Bunsen burner

Open top

Label all parts

Do not ex[plain the role of catalyst in this question

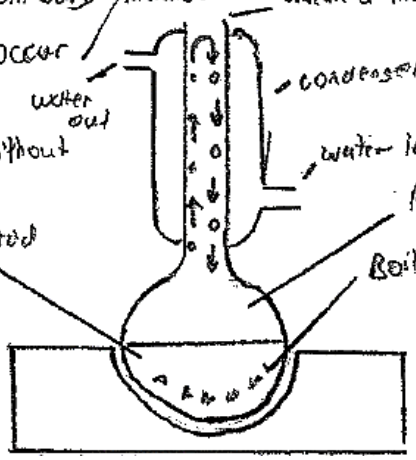
If you draw a hot plate instaed of heating mantle draw a retort stand.

Student answer attached

Question 31 (4 marks)

Explain why refluxing is used to produce an ester. Include a labelled diagram in your answer.

- Esterification involves reaction of an alcohol and carboxylic acid to produce ester
- Alcohol, carboxylic acid and esters are volatile (vapourise easily) and have low flashpoints (ignite at low temperatures)
- In esterification, heating mantle provides substantial heat to reaction mixture
- Volatile substances have high kinetic energy from heating and hence rise up flask
- Reflux condenses volatile substances from as they rise, resulting in condensing back into
- Prevents chance of fires/explosions from escaped volatile substances and prevent volatile substances from being inhaled
- Allows reaction to occur at high temperature (high KE increases rate of reaction) without compromise in safety.



• = volatile reactants

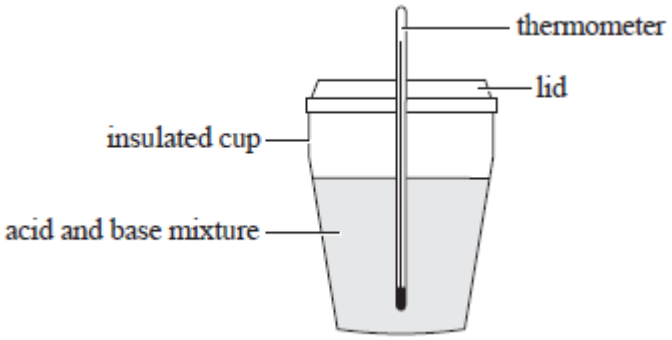
o = Condensed product + (unreacted reactants)

2

2

Question 32 (8 marks)

The diagram shows a coffee cup calorimeter used by a student to measure the enthalpy of neutralisation of an acid–base reaction.



120 mL of 0.500 mol L^{-1} sodium hydroxide was added to 60.0 mL of 0.500 mol L^{-1} sulfuric acid. Both solutions were at a temperature of 24.2°C. After mixing, the final temperature was 26.3°C.

(a) Calculate the enthalpy change per mole of water formed in this reaction. **3**

Marking criteria	**Mark**
• Gives balanced equation. AND • Performs the calculation. AND • Gives the correct answer.	3
Gives balanced equation. AND • Performs the calculation **OR** gives the correct answer.	2
• Shows some understanding of the calculation	1

$$\mathbf{H_2SO_4}(aq) + \mathbf{2NaOH}(aq) \quad \Rightarrow \quad \mathbf{Na_2SO_4}(aq) + \mathbf{2H_2O}(l)$$

1 mole of sulphuric acid (a diprotic acid) reacts with 2 moles of alkali to form 2 moles of water.

$$2H^+(aq) + 2OH^-(aq) \rightarrow 2H_2O(l)$$

$$\text{moles of water formed} = \text{moles of sodium hydroxide}$$

$$= \frac{120}{1000} \times 0.500$$

$$= 0.0600 \text{ mol}$$

$$\text{heat change } (q) = mc\Delta T$$

$$= \frac{(120 + 60)}{1000} \times 4.18 \times 10^3 \times (26.3 - 24.2)$$

$$= 0.8 \times 4.18 \times 2.1 = 1.58 \text{ kJ}$$

$$\therefore \Delta H = \frac{-q}{n(\text{water})} = \frac{-1.58 \text{ kJ}}{0.06 \text{ mol}} = -26.3 \text{ kJ mol}^{-1} \text{ (exothermic)}$$

(b) The heat of combustion of a number of alcohols was measured. The results are shown in the table. **3**

Alcohol	*Enthalpy of combustion (kJ mol^{-1})*
methanol	–726
propan-1-ol	–2021
butan-1-ol	–2676
pentan-1-ol	–3331
hexan-1-ol	–3984

Using the data provided, construct a graph that shows the relationship between chain length (number of carbon atoms) and enthalpy of combustion for these alcohols.

Marking criteria	**Mark**
• Labels axes. AND • Accurately plots points.	3
Any TWO of the above points	2
Any ONE of the above points	1

Note: Errors in use of graphing was transferred to part b calculation.
Must not extrapolate to zero

(c) Using the graph constructed in part (b), predict the value of the enthalpy of combustion of ethanol in kJ per gram of ethanol. **2**

Marking criteria	Mark
Interpolates **a value of between 1300 and 1400 kJ mol–1** as the correct molar enthalpy change from the graph. AND Converts **kJ mol–1 to kJ g–1** $-\frac{1400}{46.068}$:	2
Any ONE of the above points	1

The enthalpy of combustion of ethanol is approximately **– 1400 kJ mol^{-1}.**
The molar mass of ethanol (CH_3CH_2OH) is 46.068 g mol^{-1}.
The enthalpy of combustion of ethanol will equal approximately

$$-\frac{1400}{46.068} = -30.4 \text{ kJ g}^{-1}$$

Student sample attached

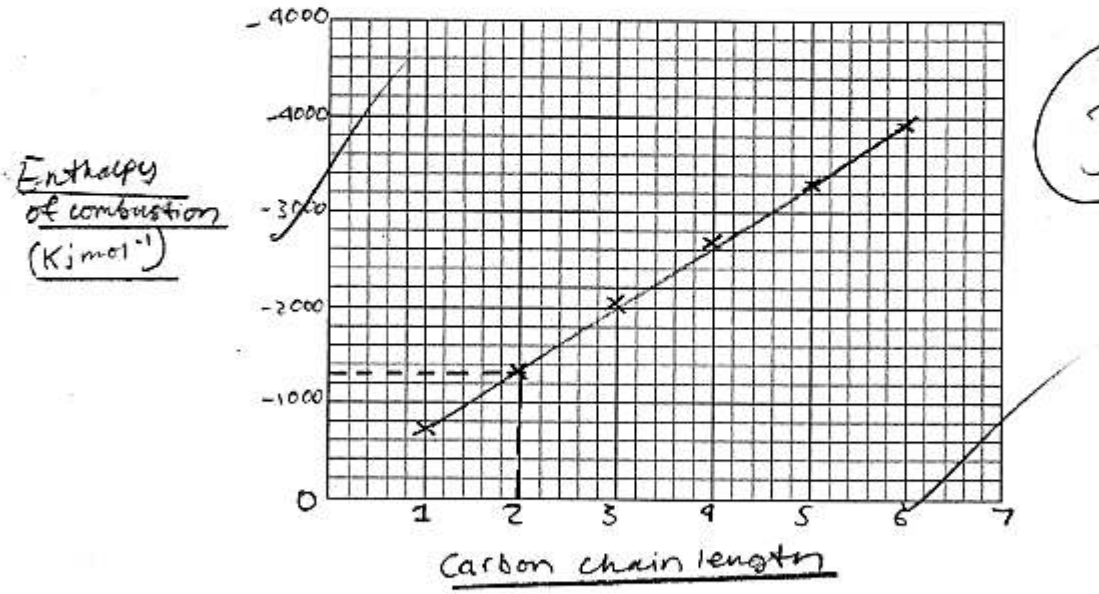
Rohan's Graph

(b) The heat of combustion of a number of alcohols was measured. The results are shown in the table. 3

Alcohol	*Enthalpy of combustion ($kJ\ mol^{-1}$)*
methanol	–726
propan-1-ol	–2021
butan-1-ol	–2676
pentan-1-ol	–3331
hexan-1-ol	–3984

Using the data provided, construct a graph that shows the relationship between chain length (number of carbon atoms) and enthalpy of combustion for these alcohols.

Enthalpy of combustion vs Chain length



3

(c) Using the graph constructed in part (b), predict the value of the enthalpy of combustion of ethanol in kJ per gram of ethanol. 2

As shown on the graph the enthalpy of combustion of ethanol is $-1360\ Kj\ mol^{-1}$ ∴ 1 mol (CH_3CH_2OH) = 46.068g

$\therefore \frac{-1360}{46.068} = -29.52157\ Kj\ g^{-1}$

$= 29.5\ Kj\ g^{-1}$ (3sf)

e

Criteria	Marks
- **A well sequenced answer written in concise clear logical order** - **Explains the principle of AAS** **AND** - Links extended response to **all stimulus material (3 stimuli)** provided: Uses **all parts** of **stimulus 1** to **explain** functions of AAS needs to use correct terminology from stimulus- -hollow cathode lamp, nebuliser, flame, monochromator, photomultiplier/computer- **detailed**. **AND** - Uses **stimulus 2 to explain calibration curves** to prepare standard solutions – needs to mention plotting of conc of known standards on a calibration curve which is then read from to determine conc of unknown **AND** - **Draws clearly lines to axes on the graph Stimulus 3** to determine **concentration of Mercury** correctly from the calibration plot as 0.50 μg L^{-1} – mercury **AND** Shows all relevant calculations as a part of the justification. This includes correct concentrated factor from evaporation and dilution factor. - Calculates the volume of water in **as 25 L** consumable by 50Kg person	**9**

e

- **Explains the principle of AAS** **AND** - Links extended response to **all stimulus material (3 stimuli)** provided: Uses **all parts** of **stimulus 1** to **explain** functions of AAS needs to use correct terminology from stimulus- -hollow cathode lamp, nebuliser, flame, monochromator, photomultiplier/computer. **Detailed** **AND** - Uses **stimulus 2 to explain calibration curves** to prepare standard solutions – needs to mention plotting of conc of known standards on a calibration curve which is then read from to determine conc of unknown **AND** - **Draws lines to axes clearly on the graph Stimulus 3** to determine **concentration of Mercury** correctly from the calibration plot as 0.50 µg L^{-1} – mercury **AND** Shows relevant calculations as a part of the justification. This includes correct concentrated factor from evaporation and dilution factor. Calculates the volume of water in **as 25 L** consumable by 50Kg person -	**8**
• Links extended response to **all stimulus** provided: **Uses ALL parts** of stimulus 1 to explain functions of AAS AND **Uses stimulus 2 to outline calibration curves** to prepare standard solutions AND **Draws clearly line to axes on the graph Stimulus 3** to determine concentration of Mercury correctly from the calibration plot as 0.50 µg L^{-1} – mercury AND Shows MOST relevant calculations as a part of the justification. This includes correct concentrated factor from evaporation and dilution factor. Calculates the volume of water in **as 25 L** consumable by 50Kg person	**7**

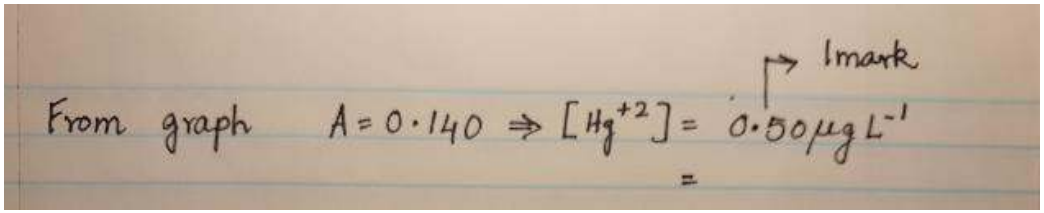
e

• Links extended response to **at least two stimuli** provided: Uses **most parts of stimulus 1** to **outline** functions of AAS Uses stimulus 2 to identify calibration curves to prepare standard solutions AND **Draws clearly on the graph** Stimulus 3 to determine concentration of Mercury correctly from the calibration plot AND **Shows most relevant calculations** as a part of the justification. This includes correct concentrated factor from evaporation and dilution factor. Calculates the volume of water in as 25 L consumable by 50Kg person	**6**
Outline s the functions of most parts of AAS **AND** Identifies concentration of Mercury correctly from the calibration plot as $0.50\ \mu g\ L^{-1} - mercury$ **AND** Makes one error in calculation - Shows all working out 5L Dilution factored in, but evaporation is not, is or vice versa	**5**
Outlines the functions of most parts of AAS **AND** Identifies concentration of Mercury correctly from the calibration plot as $0.50\ \mu g\ L^{-1} - mercury$ **AND** Calculation performed two errors-but has some logical sequence of thought 10L Dilution and evaporation not factored in	**4**

e

outlines the functions of some parts of AAS **AND** Identifies a concentration of Mercury correctly from the calibration plot as $0.50\ \mu g\ L^{-1}\ mercury$ **AND** Some calculations	**3**
outlines the functions of some parts of AAS **OR/AND** Identifies a concentration of Mercury correctly from the calibration graph. **OR/AND** Some calculations Must have **two** of the above	**2**
Some correct relevant information	**1**

Sample answer:



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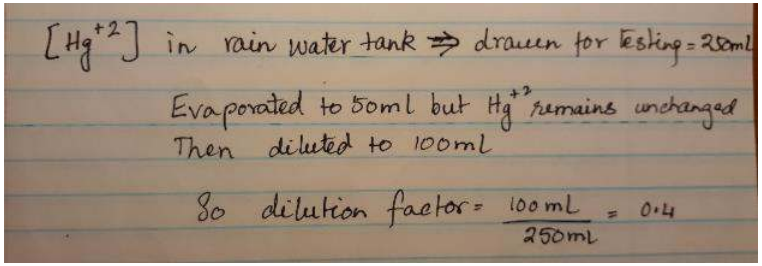
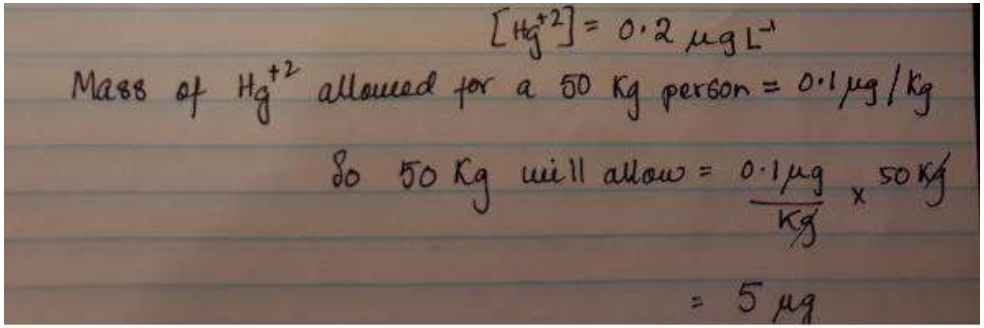
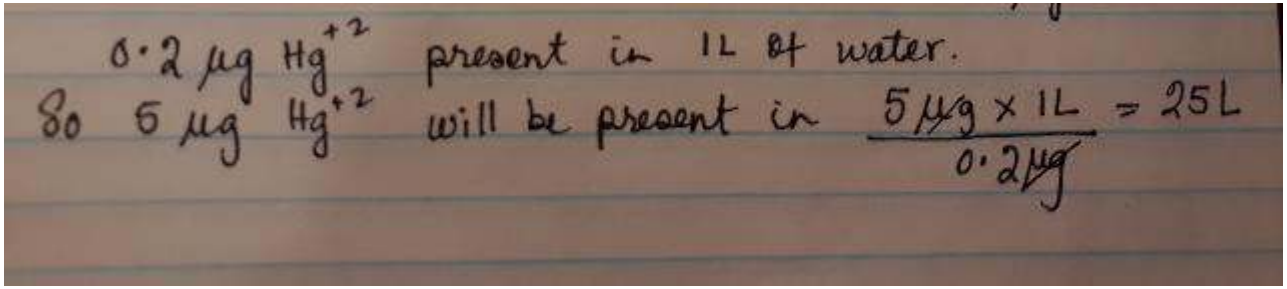

[Hg+2] in rain water tank ⇒ drawen for testing = 250ml
Evaporated to 50ml but Hg+2 remains unchanged
Then diluted to 100ml
So dilution factor = 100 mL / 250mL = 0.4


[Hg+2] = 0.2 μg L-1
Mass of Hg+2 allowed for a 50 Kg person = 0.1 μg/Kg
So 50 Kg will allow = 0.1 μg / Kg × 50 Kg
= 5 μg


0.2 μg Hg+2 present in 1L of water.
So 5 μg Hg+2 will be present in 5 μg × 1L / 0.2 μg = 25L

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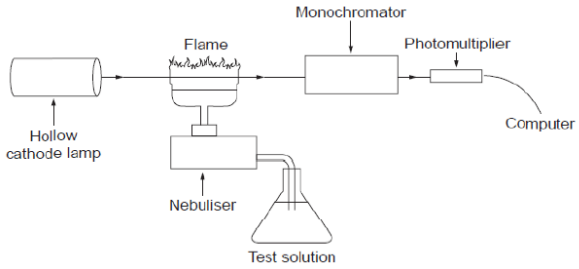
M: Identifies Mercury as a neurotoxin

Stimulus 1: A schematic diagram of the AAS used is given below.



Parts of AAS explained in detail

Describes the functions of ALL parts as shown in the diagram

(L) describes use of hollow cathode lamp

(N) sample mixed with fuel going fed into nebuliser

(F)- flame ATOMISING ions

(M) monochromator detects and analyses one specific spectral line absorbed.

(P/R/C) The readings are converted to an arbitrary reading called Absorbance. The Absorbance is directly proportional to the concentration of the atomised Metal in the flame.

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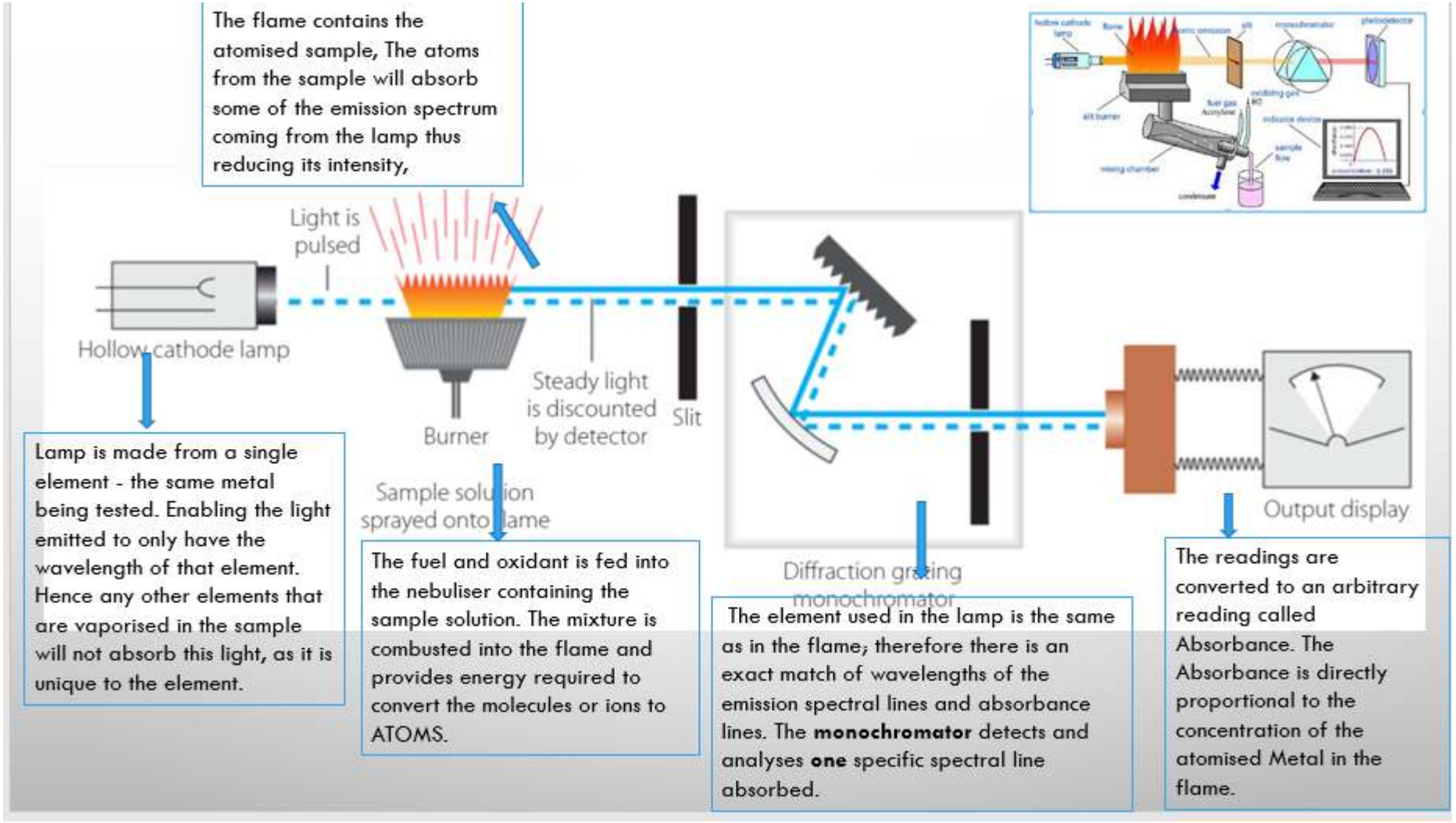

Sample answer

AAS is a very sensitive quantitative technique to determine very small quantities of metal ions in a sample (ppm or ppb)
A solution containing the sample is sprayed into a flame to create a vapour (gas) of atoms while a light beam (of a specific wavelength) is passed

e
through the flame. The electrons in the atoms absorb some of this light, making the electrons ‘jump’ to a higher energy level. The amount of the light absorbed depends on the concentration of the element in the sample. The spectra is analysed by a detection system. Each element has its own characteristic absorption spectrum that depends on the energy levels of its electrons.

Stimulus 1 reference

Lamp is made from a single element - the same metal being tested. Enabling the light emitted to only have the wavelength of that element. Hence any other elements that are vaporised in the sample will not absorb this light, as it is unique to the element.

The fuel and oxidant is fed into the **nebulise**r containing the sample solution. The mixture is combusted into the flame and provides energy required to convert the molecules or ions to ATOMS.

The flame contains the atomised sample, The atoms from the sample will absorb some of the emission spectrum coming from the lamp thus reducing its intensity,

Monochromator The element used in the lamp is the same as in the flame; therefore there is an exact match of wavelengths of the emission spectral lines and absorbance lines. **The monochromator** detects and analyses one specific spectral line absorbed.

Readings The readings are converted to an arbitrary reading called Absorbance. The Absorbance is directly proportional to the concentration of the atomised Metal in the flame.

Stimulus 2 and 3 reference

A calibration curve is constructed by - **plotting** the *amount of light absorbed by a series of standard solutions* (solutions of known concentrations that are prepared and analysed in AAS) against the *concentration of the element.* ie concentration *vs* absorbance

Unknown is analysed with AAS and the reading from calibration curve determines the concentration of the mercury sample.

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Calculation

250 mL **evaporated** to 50 mL therefore **concentration of Hg^{2+} increases by 5.**

Then 50 mL is made up to 100mL in a volumetric flask- therefore sample **diluted by 2**

Sample tested is **2.5 times more concentrated than original sample**

Reading of sample from calibration curve is **A = 0.14 – concentration is 0.5µg/L.**

However this concentration is 2.5 times greater than original sample.

Original sample is 0.5/2.5 = 0.2 µg/L

Therefore [Hg^{2+}] in original sample is 0.2 µg/L

EPA standard is 0.1 µg/Kg, therefore for a 50 Kg person the maximum level accepted is 0.1µg x 50 = 5µg in total

Since there is 0.2 µg/L in the samples taken the maximum amount of water that can be consumed would be **5/0.2 = 25 L**