Student Name: _____

Please highlight/circle your teacher's name

Mrs V. Agapides
Mrs R. Campbell
Mrs D. Greener
Mrs E. Lyons
Mrs J. Kennedy
Mrs A. Thorne

Pymble Ladies' College

SEMESTER 2, 2023

YEAR 11 CHEMISTRY

EXAMINATION

READING TIME: 5 minutes

TIME ALLOWED: 2 HOURS

TOTAL MARKS: 90

DIRECTIONS TO CANDIDATES

Write your name in the space at the top of the page where indicated and circle your teacher.

PART A: 20 multiple choice questions, each worth one mark.
Indicate your answers on the multiple choice answer sheet.

PART B: Extended response questions (Total of 70 marks).
Marks for each question are indicated.
Answer each question in the space provided.

- Write using black pen only
- The lined spaces in the question booklet are a guide to the expected length of your answer.
- Show all relevant working and calculations.
- Extra writing paper found at the back of the paper

A separate Periodic Table and Data Sheet are provided.

PART A

Total Marks – 20

Attempt ALL questions

Select the alternative that best answers the question.

[Allow about 20 minutes for this part]

1. Which of the following substances will conduct electricity in both the solid and liquid states?

   A. lithium fluoride

   B. silicon dioxide

   C. sodium

   D. sulfur

2. What is the correct systematic (IUPAC) name for $Al_2(SO_4)_3$?

   A. Aluminium sulfate

   B. Aluminium sulfur oxide

   C. Aluminium trisulfate

   D. Dialuminium sulfate

3. The melting and boiling points of 4 elements are listed below.

Element	*Melting Point (°C)*	*Boiling Point (°C)*
W	-39	357
X	232	2270
Y	-101	-35
Z	217	685

Which element will be liquid at room temperature (25°C)?

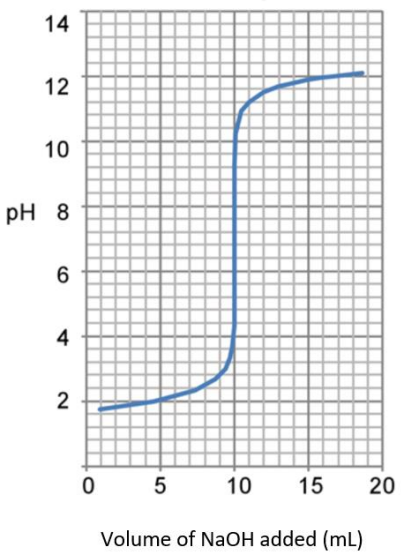
   A. W

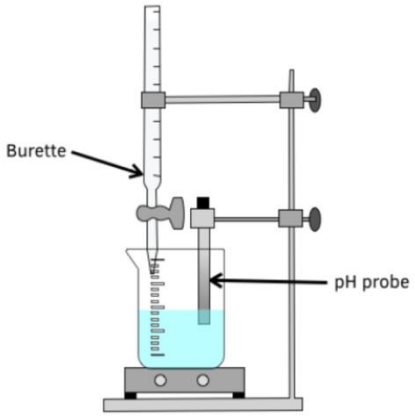
   B. X

   C. Y

   D. Z

4. A student used the equipment setup shown below to add sodium hydroxide (NaOH) solution to a beaker containing hydrochloric acid (HCl). The results were graphed as shown below.





Identify the correct independent and dependent variable the student should use for the graph title.

	Independent variable	*Dependent variable*
A.	Volume of HCl added	pH value
B.	pH value	Volume of NaOH added
C.	Volume of NaOH added	pH value
D.	Volume of NaOH added	Volume of HCl added

5. Which list of substances contains only compounds with ionic bonds?

   A. potassium chloride, magnesium oxide, copper(II) chloride.
   B. potassium chloride, magnesium nitrate, carbon dioxide.
   C. magnesium oxide, copper(II) chloride, sulfur trioxide.
   D. magnesium nitrate, potassium oxide, carbon dioxide.

6. Laboratory tests established the following properties for sulfur, carbon and iron.

Test	*Sulfur*	*Carbon*	*Iron*
Solubility in water solvent	insoluble	insoluble	insoluble
Solubility in carbon disulfide solvent	soluble	insoluble	insoluble
Attraction to a magnet	unattracted	unattracted	attracted

A powdered mixture contains sulfur, carbon and iron. Which of the following describes a procedure which would separate all the compounds to give the pure solid components?

	Step 1	*Step 2*	*Step 3*	*Step 4*
A.	Magnetic separation	Add water	Filtration	Distillation
B.	Sieve	Add carbon disulfide	Decant	Evaporation
C.	Add water	Filtration	Crystallisation	Magnetic separation
D.	Magnetic separation	Add carbon disulfide	Filtration	Evaporation

7. Curium is produced according to this equation.

$$^{239}_{94}\text{Pu} + \text{X} \longrightarrow {}^{242}_{96}\text{Cm} + {}^{1}_{0}\text{n}$$

What is X in the equation?

A. A proton

B. A neutron

C. A beta particle

D. An alpha particle

8. What is the empirical formula for a compound that is 79.85 % Carbon and 20.15% hydrogen?

A. CH_4

B. CH_3

C. C_2H_6

D. C_4H

9. At constant temperature and pressure, 6.0 L of CO is combined with 3.0 L of O_2 according to the equation:

$$2CO\,(g) + O_2\,(g) \rightarrow 2CO_2\,(g)$$

What is the total volume of gas present once the reaction had gone to completion?

A. 5.5 L

B. 6.0 L

C. 6.5 L

D. 8.0 L

10. Referring to the balanced equation below, identify the values of X and Y in this equation:

$$XNH_3(g) + 7O_2\,(g) \rightarrow YNO_2(g) + 6H_2O(g)$$

A. X= 4, Y= 2

B. X= 3 , Y= 3

C. X= 7, Y= 6

D. X= 4, Y= 4

11. Identify the compound in which manganese has an oxidation number of +4.

A. MnO_2
B. $KMnO_4$
C. Mn_2O_3
D. $MnSO_4$

12. Iodine-131 has a half-life of 8.00 days. How long does it take for 120g to decay to 7.50g?

A. 4 days
B. 16 days
C. 32 days
D. 128 days

13. For which pair of substances will a displacement reaction occur?

A. Copper in a solution of aluminium ions
B. Lead in a solution of nickel ions
C. Iron in a solution of zinc ions
D. Magnesium in a solution of silver ions

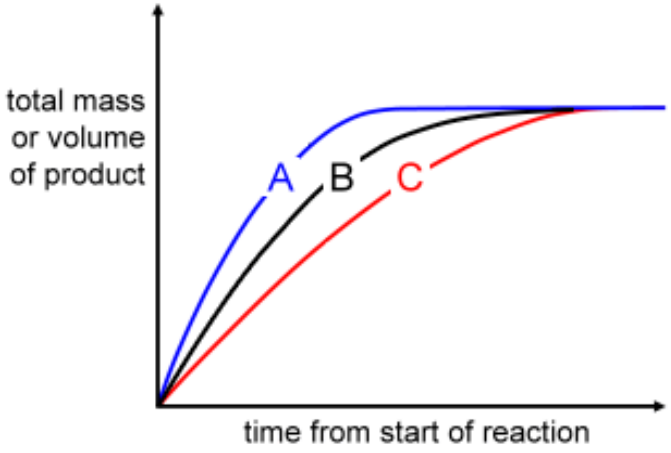
14. The first six ionisation energies, in kJ mol^{-1}, of an element are:

1090, 2350, 4610, 6220, 37 800, 47 000

What is the element?

A. Boron
B. Carbon
C. Nitrogen
D. Oxygen

15. Students investigating the factors which influence the rates of chemical reactions recorded graphs A, B, and C for three reactions using identical reactants and numbers of moles.



Which of the following is a CORRECT statement?

A. Reaction A produces the most product.
B. Reaction A occurred slower than reaction B and C.
C. The reactants are consumed more rapidly in reaction A than in reactions B and C.
D. The reactants are consumed more slowly in reaction A than in reactions B and C.

16. How many oxygen atoms are present in a 10.0g sample of CO_2 gas?

A. 1.37×10^{23}
B. 2.73×10^{23}
C. 4.10×10^{23}
D. 6.022×10^{23}

17. Two atoms X and Y have electronic configurations as shown below:

X $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$
Y $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

What compound is most likely to form when X and Y combine?

A. ionic, with formula X_2Y
B. ionic, with formula XY_2
C. covalent, with formula XY_4
D. covalent, with formula X_2Y_5

18. The element neon has three isotopes with abundances as shown in the table:

Isotope symbol	Abundance
$^{20}_{10}Ne$	90.920%
$^{21}_{10}Ne$	0.25990%
$^{22}_{10}Ne$	8.8201%

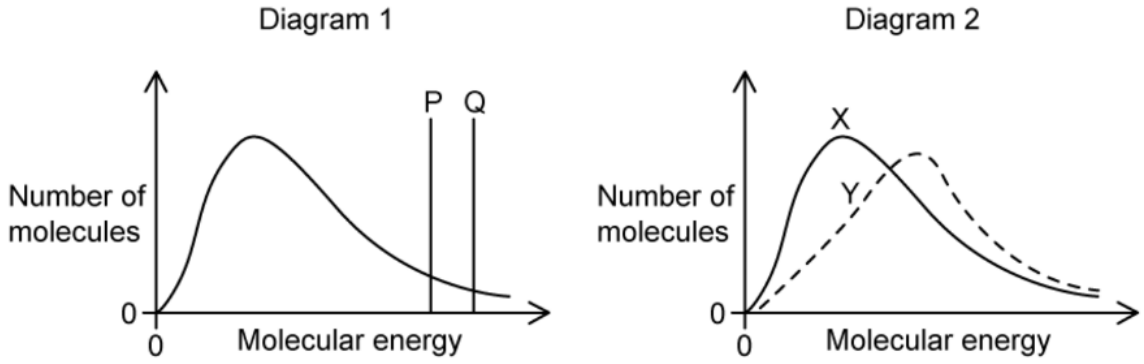
What is the atomic mass of neon?

A. 20.201
B. 20.184
C. 20.179
D. 20.108

19. 0.422 g of an element Z reacts with oxygen to form 0.797 g of the oxide Z_2O_3. What is element Z?

A. gallium
B. scandium
C. chromium
D. aluminium

20. The diagrams below show the Maxwell- Boltzmann distribution of molecular energies in a sample of gas.



In *diagram 1*, one line P or Q, corresponds to the activation energy in the presence of a catalyst and the other line corresponds to the activation energy of the same reaction in the absence of a catalyst.

In *diagram 2,* one curve, X or Y, corresponds to a temperature higher than that of the other curve.

Which combination give the correct line and curve?

	Presence of a catalyst	**Higher temperature**
A.	P	X
B.	P	Y
C.	Q	X
D.	Q	Y

PART B

Total marks – 70

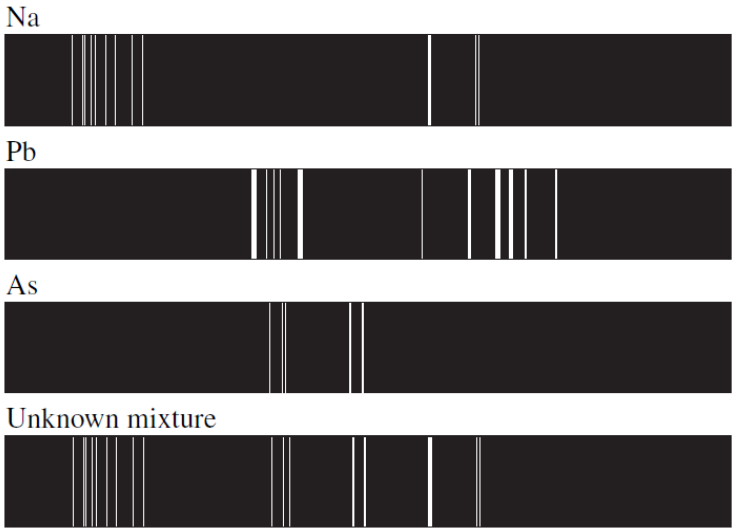
Attempt ALL questions

Show all relevant working in questions involving calculations.

[Allow about 1 hour and 40 minutes for this part]

Question 21 (5 marks)

The diagram shows the emission spectra of three elements and an unknown mixture.



(a) Name TWO elements present in the unknown mixture. **2**

……..

……..

(b) Explain why an emission spectrum is unique to an element. **3**

……..

……..

……..

……..

……..

Question 22 (3 marks)

The table below shows the electronegativity values of atoms of some elements.

Atom	H	C	N	O	Br
Electronegativity	2.1	2.5	3.0	3.5	2.8

a) Define the term electronegativity.

1

……..

……..

……..

b) From the table deduce the **two** atoms that will form the most polar bond. Use a diagram to represent the polarity of the bond.

2

……..

……..

Question 23 (6 marks)

Fluorine forms different types of compounds with various elements.

Examples are sodium fluoride (NaF), tetrafluoromethane (CF_4) and hydrogen fluoride (HF). Some properties of these compounds are listed below.

Compound	*Boiling point (°C)*	*Conductivity in liquid state*
NaF	1695	high
CF_4	-128	low
HF	20	low

Explain in terms of chemical bonding why the properties of NaF, CF_4 and HF are different? **6**

……

……

……

……

……

……

……

……

……

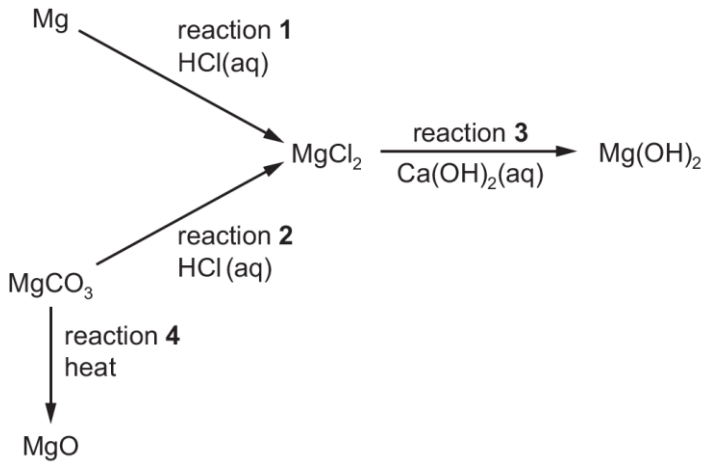
……

……

Question 24 (8 marks)

Figure 1 shows some reactions of magnesium and its compounds. Table 1 (on page 15) shows some relevant solubility rules.

Figure 1: some reactions of magnesium



(a) Identify ALL the other products of reactions **1** and **2**. **2**

Reaction **1** …….

Reaction **2** …….

(b) State the type of reaction that occurs in reaction **4.** **1**

……..

(c) Justify a test you could use in the laboratory to show this type of reaction is occurring. **2**

……..

……..

……..

……..

Question 24 continues on page 15

Question 24 (continued)

Table 1: Solubility rules

Soluble Ionic Compounds		***Important Exceptions***
Compounds containing	NO_3^-	None
	CH_3COO^-	None
	Cl^-	Compounds of Ag^+, Hg_2^{2+} and Pb^{2+}
	Br^-	
	I-	
	SO_4^{2-}	
Insoluble Ionic Compounds		***Important Exceptions***
Compounds containing	S^{2-}	Compounds of NH_4^+, and the alkali metal cations and Ca^{2+}, Sr^{2+} and Ba^{2+}
	CO_3^{2-}	Compounds of NH_4^+, and the alkali metal cations
	PO_4^{3-}	Compounds of NH_4^+, and the alkali metal cations
	OH^-	Compounds of NH_4^+, and the alkali metal cations and Ca^{2+}, Sr^{2+} and Ba^{2+}

(d) Reaction **3** is used to form a precipitate of $Mg(OH)_2$ from a $MgCl_2$ solution.
Write a neutral species equation for this reaction.

2

…….

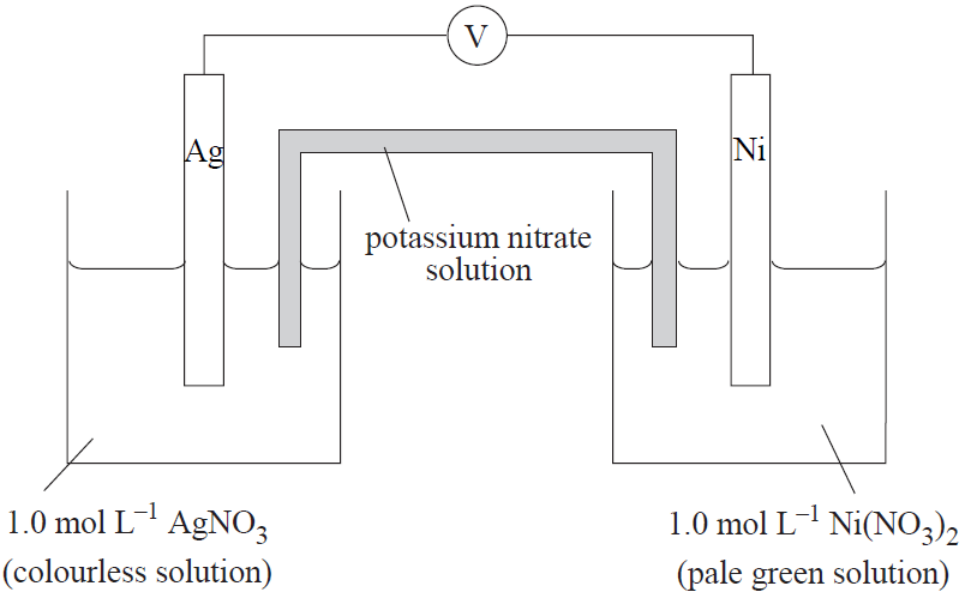
(e) Identify *another* solution that could be added to aqueous magnesium chloride to produce magnesium hydroxide.

1

…….

Question 25 (12 marks)

An electrochemical cell was set up in the laboratory as shown.



(a) On the **diagram above**, label the anode, cathode, the direction of the electron flow, the direction of ion flow in the salt bridge and indicate the charge of each electrode.

4

(b) Write the following chemical equations that occur in the electrochemical cell.

(i) Reduction half equation:

1

……..

(ii) Oxidation half equation:

1

……..

(iii) Net ionic equation

2

……..

……..

(c) Calculate the theoretical cell voltage. Show your working.

2

……..

……..

……..

……..

Question 25 continues on page 17

Question 25 (continued)

(d) Describe the changes the student would observe in each half cell if the reaction proceeded until no further change took place.

2

……..

……..

……..

……..

Question 26 (9 marks)

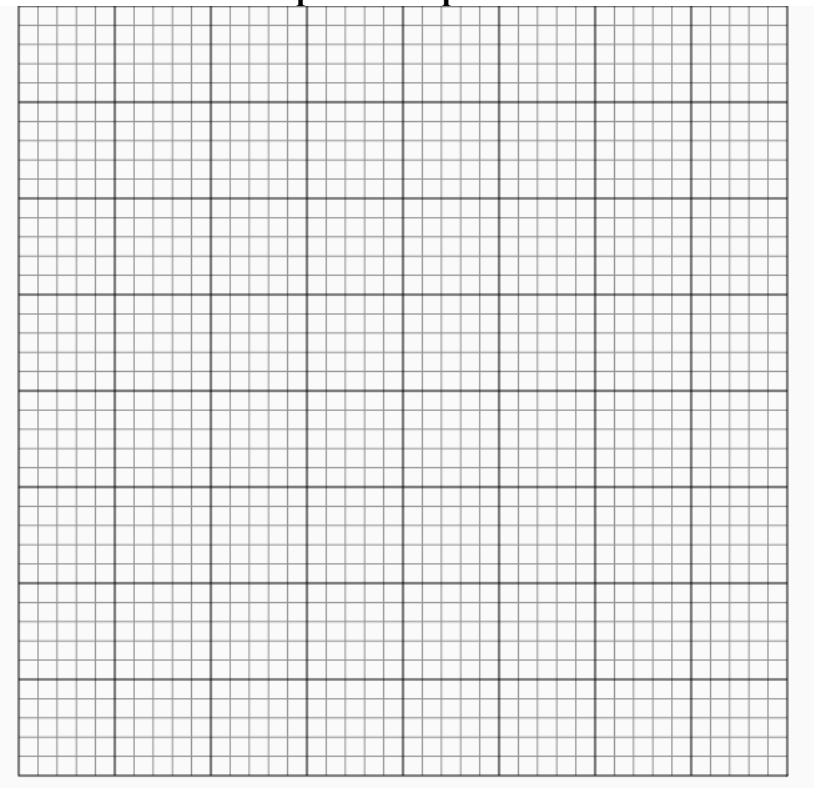
During a study of Ideal Gas Laws, a student was asked to discover how the volume of a sample of gas depends on pressure. The student measured the volume of a sample of hydrogen gas at different pressures. The experiment was carried out at 25°C and the results were recorded in the table below.

Pressure (kPa)	*Volume (mL)*
148	15
117	19
85	26
70	31
63	36

(a) Plot the results, including a curved line of best fit.

3

The relationship between pressure and volume.



Question 26 continues of page 19

Question 26 (continued)

(b) What relationship between pressure and volume can be derived from these results? **1**

…….

…….

(c) Use your graph to estimate the volume of hydrogen gas at 140 kPa. **1**

…….

…….

(d) Use a Gas Laws calculation to mathematically show your answer to part (c) is correct. **2**

……..

……..

(e) Find the number of moles of hydrogen used in the experiment. **2**

……..

……..

……..

……..

End of Question 26

Question 27 (5 marks)

Two gases, X and Y, react to form a third gas, Z.

$$2X(g) + Y(g) \rightarrow 2Z(g)$$

3.00 L of gas X at room temperature and pressure (RTP), 25 °C and 100 kPa, is used as a reactant.

Gas Y, also used as a reactant, occupies 3.00 L at a pressure of 106 kPa and a temperature of 20 °C.

(a) Show that the volume of gas Y increases to about 3.2 L at RTP. **2**

……

……

……

……

(b) After the reaction is complete, the gas mixture is returned to RTP.

Calculate the new volume of the gas mixture after the reaction at RTP. **3**

……

……

……

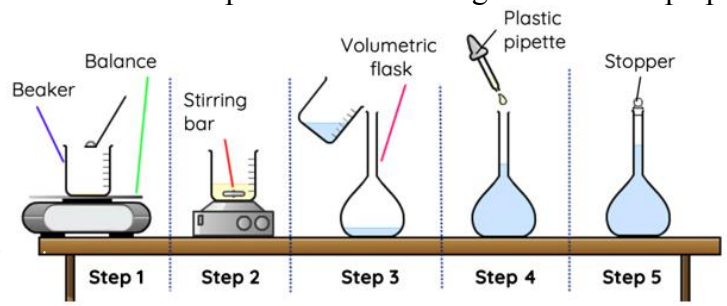
……

……

……

Question 28 (9 marks)

A chemist is required to accurately make up 500 mL of a 0.0500 mol L^{-1} solution from solid sodium carbonate. She used the 5 steps shown in the diagram below to prepare the solution.



(a) What mass of sodium carbonate is required? **3**

……..

……..

……..

……..

……..

……..

(b) The chemist accidently went over the line in step 4. She used the pipette to remove the extra drops until the meniscus lay correctly on the line. Explain the impact this will have on her solution.

2

……..

……..

……..

……..

(c) The chemist realised her mistake and correctly made a new 0.0500 mol L^{-1} sodium carbonate solution. What volume of 0.0890 mol L^{-1} HCl would be required to react completely with 25.0 mL of the new sodium carbonate solution?

4

……..

……..

……..

……..

……..

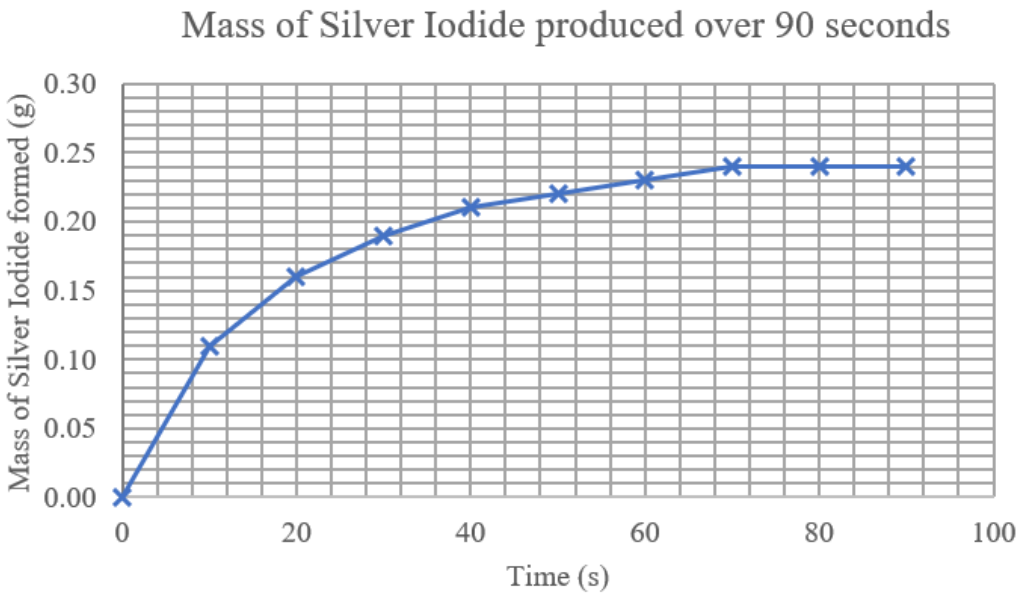
……..

……..

Question 29 (13 marks)

Identical concentrations (unknown) and volumes (10 mL) of aqueous sodium iodide and silver nitrate were reacted together over a minute and a half. The mass of the precipitate was recorded every 10 seconds.

The graph below shows the mass of silver iodide formed over 90 seconds.



(a) Identify the time period where the rate of the reaction was the fastest.

1

……

(b) Identify the mass of silver iodide formed when the reaction had finished.

1

……

(c) Use *Collision Theory* to explain the graphed data.

4

……

……

……

……

……

……

……

……

Question 29 continues on page 22

Question 29 (continued)

(d) Calculate the concentration of the initial sodium iodide. **3**

…….

…….

……..

…….

……..

…….

(e) Assuming all possible insoluble ions had fully precipitated out of solution and were filtered out of the solution, calculate the concentration of the remaining solution. **4**

…….

…….

……..

…….

……..

…….

……..

…….

END OF PAPER

2023 Year 11 – Yearly Marking Guidelines

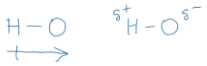
MULTIPLE CHOICE

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

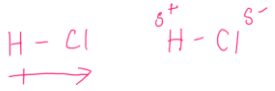
Q	Marking Guideline	Suggested Answer	Markers Feedback
21a	<table><tr><th>Criteria</th><th>Mark</th></tr><tr><td>Identifies two elements correctly</td><td>2</td></tr><tr><td>Identifies 1 element</td><td>1</td></tr></table>	Sodium and Arsenic	
21b	<table><tr><th>Criteria</th><th>Mark</th></tr><tr><td>Correctly explains • why light is given out • each element has unique electron arrangement • that specific wavelengths of light given out</td><td>3</td></tr><tr><td>Shows some understanding of why an emission spectra is unique to an element</td><td>2</td></tr><tr><td>Provides some relevant information</td><td>1</td></tr></table>	Spectra is produced when electrons in the atom drop from an excited state back to ground level giving out photons of light. Each element has a specific arrangement of electrons with distinct energy levels so the wavelengths of light emitted are specific to each element. An emission spectrum is unique to an element due to its specific arrangement of electrons in atom energy levels. When electrons move from higher to lower energy levels, they emit light with precise wavelengths. Since each element has distinct energy level patterns, their emitted light forms a distinct pattern of lines. 1 mark – identifies an atom has different electron energy levels / shells 1 mark – identifies emission occurs when electron falls from an excited to ground state 1 mark – relates energy to wavelengths in line spectrum	

<table>
<tr>
<td>22 a</td>
<td>
<table>
<tr><td>Criteria</td><td>Mark</td></tr>
<tr><td>Correctly calculates AM</td><td>1</td></tr>
</table>
</td>
<td>Tendency/ability of an atom to attract electrons to its outer shell/ towards itself</td>
<td></td>
</tr>
<tr>
<td>22 b</td>
<td>
<table>
<tr><td>Criteria</td><td>Mark</td></tr>
<tr><td>• Identifies two atoms correctly
• Draws correct diagram</td><td>2</td></tr>
<tr><td>Draws correct diagram with incorrect atoms</td><td>1</td></tr>
</table>
</td>
<td>Oxygen and hydrogen

Drawing:

Hydrogen and chlorine

Drawing:  </td>
<td></td>
</tr>
</table>

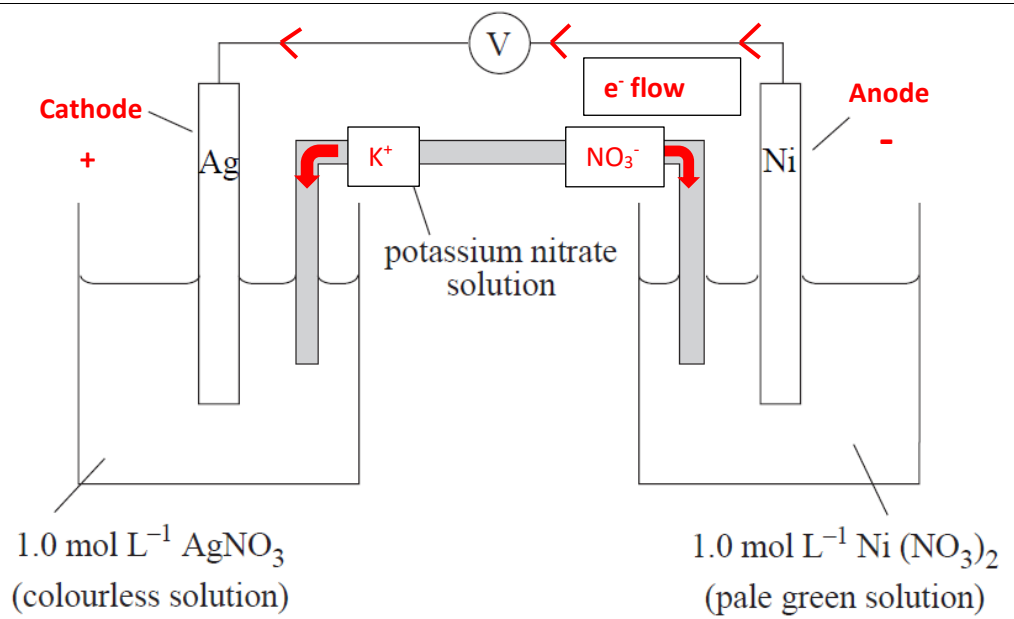
23	<table><tr><th>Criteria</th><th>Mark</th></tr><tr><td>Shows an extensive understanding and includes: • Correctly identifies the intramolecular and intermolecular forces in each compound • Explains reasons for the differences in boiling points including relative strengths of IMFs • Explains reasons for the differences in conductivity (presence of mobile ions or mobile electrons)</td><td>6</td></tr><tr><td>Shows a thorough understanding of why the 3 substances have different properties. OR Shows an understanding of SOME properties</td><td>5-4</td></tr><tr><td>• Explains reasons for the differences in boiling points OR • Explains reasons for the differences in conductivity</td><td>2-3</td></tr><tr><td>Provides some relevant information</td><td>1</td></tr></table>	NaF is an ionic compound and therefore conducts in a liquid state as the ions are free to move around. It has a high a boiling point due to the strong electrostatic forces between oppositely charged ions which require a large amount of energy to overcome. Conversely CF_4 and HF are both covalent molecules which do not conduct as their electrons are fixed in covalent bonds between atoms, nor do they contain mobile ions. CF_4 and HF's boiling points are much lower than NaF as only weak intermolecular forces between molecules have to be overcome in boiling the substance. CF_4 is a molecular substance and is non polar because it is symmetrical (even though it has polar bonds.) The only force that needs to be broken to boil this substance are weak IMF (dispersion forces) HF is a POLAR molecule. Because of the highly electronegative F attached to a hydrogen, the IMF that exists between the molecules is Hydrogen bonding. This is not as strong as the electrostatic forces in the ionic lattice b ut significantly stronger than the dispersion forces in CF4. These IMF need more energy to overcome so thus a higher Boiling point.	Girls need to be really careful of the correct use of scientific terminology here. There is a lot of misunderstanding about the conductivity of ionic substances. The conductivity is due to the mobile ions in the liquid state NOT ELECTRONS. The covalent molecules do not have either mobile electrons nor mobile ions. Relative strength of dispersion forces and hydrogen bonds was also missing in a lot of responses. Many girls missed out on referring to BOTH lots of data. Many also just rewrote what the questions was asking.

<table>
<tr>
<td>24 a)</td>
<td>
<table>
<tr><td>Criteria</td><td>Mark</td></tr>
<tr><td>Identifies all other products</td><td>2</td></tr>
<tr><td>Identifies some correct products</td><td>1</td></tr>
</table>
</td>
<td>Reaction 1 – H_2
Reaction 2 – CO_2 and H_2O</td>
<td>Was generous in marking this one. As long as you correctly identify one product a mark was awarded</td>
</tr>
<tr>
<td>24 b)</td>
<td>
<table>
<tr><td>Criteria</td><td>Mark</td></tr>
<tr><td>Correctly identifies type of reaction</td><td>1</td></tr>
</table>
</td>
<td>Decomposition</td>
<td>Common error here was identifying reaction as combustion.</td>
</tr>
<tr>
<td>24 c)</td>
<td>
<table>
<tr><td>Criteria</td><td>Mark</td></tr>
<tr><td>Identifies test
Justifies test using positive result</td><td>2</td></tr>
<tr><td>Identifies test</td><td>1</td></tr>
</table>
</td>
<td>Limewater turns milky in the presence of CO_2 which shows $MgCO_3$ has broken down into a simpler compound.

OR

MgO is an oxide of a metal and can be mixed with water and tested with UI to show blue/purple colour to show basic pH confirming that $MgCO_3$ has broken down into a simpler compound.</td>
<td>.
I was generous.

Many only received 1 mark here if you did not identify what the positive test result would show.</td>
</tr>
<tr>
<td>24 d)</td>
<td>
<table>
<tr><td>Criteria</td><td>Mark</td></tr>
<tr><td>Correct equation
Correct states
Correct formulae</td><td>2</td></tr>
<tr><td>As above with error</td><td>1</td></tr>
</table>
</td>
<td>$Ca(OH)_2$ (aq) + $MgCl_2$ (aq) → $Mg(OH)_2$(s) + $CaCl_2$(aq)</td>
<td>Generally well answered, most formulas were supplied in the question.
Many lost a mark due to incorrect states, as this is a precipitation reaction stated are important.</td>
</tr>
<tr>
<td>24 e)</td>
<td>
<table>
<tr><td>Criteria</td><td>Mark</td></tr>
<tr><td>Correct solution</td><td>1</td></tr>
</table>
</td>
<td>Barium Hydroxide or Strontium hydroxide or ammonium hydroxide or alkali metal hydroxide</td>
<td>A solution is a soluble salt which means you needed to identify a soluble hydroxide that could be added to produce magnesium hydroxide. If you only stated hydroxide you did not get the mark.</td>
</tr>
</table>

<table>
<tr>
<td>25 a</td>
<td>
<table>
<tr><th>Criteria</th><th>Mark</th></tr>
<tr><td>• Correct label of anode and cathode
• Correct label of positive and negative electrode
• Correct direction for flow of electrons
• Correct flow of salt bridge ions</td><td>4</td></tr>
<tr><td>3 correct aspects</td><td>3</td></tr>
<tr><td>2 correct aspects</td><td>2</td></tr>
<tr><td>1 correct aspect</td><td>1</td></tr>
</table>
</td>
<td> 
</td>
<td>Error carried forward (e.c.f) for electron flow/ions/charge if cathode and anode wrong.

Fairly well answered. Many students missed labelling the positive and negative charge on the electrodes.</td>
</tr>
<tr>
<td>25 b (i)</td>
<td>
<table>
<tr><th>Criteria</th><th>Mark</th></tr>
<tr><td>Correct half equation for reduction half cell</td><td>1</td></tr>
</table>
</td>
<td>$Ag^+(aq) + e^- \rightarrow Ag(s)$</td>
<td>e.c.f if cathode and anode incorrect in part a)
Please include state symbols (no marks lost this time)</td>
</tr>
<tr>
<td>25 b (ii)</td>
<td>
<table>
<tr><th>Criteria</th><th>Mark</th></tr>
<tr><td>Correct half equation for oxidation half cell</td><td>1</td></tr>
</table>
</td>
<td>$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$</td>
<td>e.c.f if cathode and anode incorrect in part a)</td>
</tr>
<tr>
<td>25 b (iii)</td>
<td>
<table>
<tr><th>Criteria</th><th>Mark</th></tr>
<tr><td>Correct balanced net ionic equation</td><td>2</td></tr>
<tr><td>Correct equation</td><td>1</td></tr>
</table>
</td>
<td>$2Ag^+(aq) + Ni(s) \rightarrow 2Ag(s) + Ni^{2+}(aq)$</td>
<td>e.c.f if cathode and anode incorrect in part a)</td>
</tr>
</table>

25 c

Criteria	Mark
Correct E_{cell} With working	2
Correct value, no working. OR Calculates value with incorrect working	1

$E_{cell} = E_{ox} + E_{red}$

$E_{cell} = 0.24 + 0.80 = 1.04$ V

e.c.f if cathode and anode incorrect in part a)

Remember to change the symbol for oxidation (negative to positive)

25 d

Criteria	Mark
Correct observation in each half cell	2
A correct observation	1

In the Nickel half cell

- solution would become a darker green colour
- -Ni electrode decreases in mass

In the Silver half cell

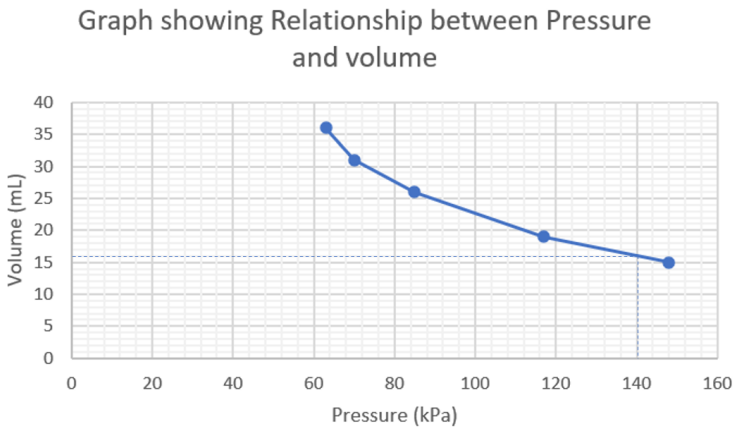
- The electrode has silver deposits on it

Ecf e.c.f if cathode and anode incorrect in part a)

- Silver electrode decreases in mass
- Nickel deposits on the Ni electrode (mass increases)

26 a)

Criteria	Mark
• Plots the points on the graph correctly • Draws a curved line of best fit within range • Even scale • Correct axes (Iv on x axis, labels with units)	3
2-3 of the above	2
Provides some relevant information	1



P - plotting
L – line of best fit
A - axes
S – scale

If your curve is beyond the range of the given data you did not get the mark for the line of best fit.

Plotting – the mark was lost if you had a point that was 1 square or more wrong.

26 b)

Criteria	Mark
Correct derivation	1

Volume is inversely proportional to pressure

$V \propto 1/P$

<table>
<tr>
<td>26 c)</td>
<td>
<table>
<tr><th>Criteria</th><th>Mark</th></tr>
<tr><td>Correct value for volume a 140 kPa</td><td>1</td></tr>
</table>
</td>
<td>Volume at 140 kPa is 16 mL – this value must come from the graph (be within 0.5)

Volume at 100 kPa is 22.5 mL</td>
<td>A lot of students said 16mL when their graph actually read 15.5mL. The best answers showed working on the graph (i.e. dotted line drawn from the x axis at 140 kPa to the line of best fit and then another line drawn from there to the y axis).</td>
</tr>
<tr>
<td>26 d)</td>
<td>
<table>
<tr><th>Criteria</th><th>Mark</th></tr>
<tr><td>Correct calculation</td><td>2</td></tr>
<tr><td>1 relevant step</td><td>1</td></tr>
</table>
</td>
<td>P1V1 = P2V2, use a data point from data table or graph:

117 x 19 = 140 V2 Hence, V2 = 15.87 L Graph value is an estimate.

117 x 19 = 100 V2 Hence, V2 = 22.23 L Graph value is an estimate.</td>
<td>A couple of alternative methods were used by a few students:
1) use P1V1 = k twice, once with values from table and second time using 140 and answer to c and show that the constants were the same.
2) calculate n in PV=nRT using 2 values from the table. Then calculate V using the same equation and the answer to n subbed in.</td>
</tr>
<tr>
<td>26 e)</td>
<td>
<table>
<tr><th>Criteria</th><th>Mark</th></tr>
<tr><td>Correct calculation</td><td>2</td></tr>
<tr><td>Some correct steps</td><td>1</td></tr>
</table>
</td>
<td>PV = nRT

117 x 0.019 = n x 8.314 x 298.15

n = 2.223/2478.8191 = 0.000896797….. moles $9.0x10^{-4}$

Alternative method
- Read off value for volume for 100kPa
- Use molar volume of a gas
- n = V/Mv</td>
<td>Many students forgot to convert the volume to L before calculating PV=nRT</td>
</tr>
<tr>
<td>27 a</td>
<td>
<table>
<tr><th>Criteria</th><th>Mark</th></tr>
<tr><td>Correct calculation</td><td>2</td></tr>
<tr><td>Some correct steps</td><td>1</td></tr>
</table>
</td>
<td>P1V1/T1 = P2V2/T2
(106 x 3)/293.15 = (100 x V2)/298.15
V2 = 3.23 L
OR,
n = PV/TR = 106 x 3/(8.31 x 293.15) = 0.1305377725
V = n x 24.79 = 0.1305377725 x 24.79 = 3.2360 L</td>
<td>Many girls failed to recognise that they had to use pressure, temperature and volume in their calculation and so only received 1 mark. EACH of these conditions were changed for Y.</td>
</tr>
</table>

27 b	<table><tr><td>Criteria</td><td>Mark</td></tr><tr><td>Correct calculation Shows all working</td><td>3</td></tr><tr><td>Correct calculation with minor error</td><td>2</td></tr><tr><td>Some relevant steps</td><td>1</td></tr></table>	**VOLUMES SOLUTION** 2X + Y forms 2Z 3 L of X forms 3 L of Z 3 L of X reacts with 1.5 L of Y We have 3.2 L of Y (from above) so this reagent is INXS So X is the limiting reagent and there will be 1.7 L of Y left over. So the mixture of gases after the reaction is 3L of Z + 1.7 L of Y = 4.7L of gases. MOLES SOLUTION n(X) = 3.00/24.79 = 0.1210165389 mol n(Y) = 0.1305377725 mol 0.1210165389/2 < 0.1305377725 Hence X is LR n(Z) = n(X) = 0.1210165389 mol ∴ V(Z) = 3.00 L n(Y)excess = 0.1305377725 – (0.1210165389/2) = 0.070029503 mol V(Y) = 0.070029503 x 24.79 = 1.736 L V(total) = 3.00 + 1.736 = 4.74 L	This is a simple Gay Lussac /Avagadro's law equation. But it also involved including a limiting reagent in it. The complicated way of doing this was to convert back to moles, but there was absolutely no need to do this. (VOLUME solution opposite) LOTS of girls failed to recognise that X and Y formed Z. They not only had to calculate how much Z formed but also to look at how much Y was left over.

<table>
<tr>
<td>28 a</td>
<td>
<table>
<tr><th>Criteria</th><th>Mark</th></tr>
<tr><td>Correctly calculates:
• Moles of Na_2CO_3 needed
• Molar mass of Na_2CO_3
• Mass of Na_2CO_3</td><td>3</td></tr>
<tr><td>2 relevant calculations</td><td>2</td></tr>
<tr><td>1 relevant calculation</td><td>1</td></tr>
</table>
</td>
<td>
$n = c \times v$
$n = 0.05 \times \frac{500}{1000}$
$n = 0.025$

MM = (2 x 22.99) + 12.01 + (3 x 16)
MM = 105.99

m = n x MM
m = 0.025 x 105.99
m = 2.65g (3sf)

$n = c \times v$
$n = 0.06 \times \frac{500}{1000}$
$n = 0.030$

MM = (2 x 22.99) + 12.01 + (3 x 16)
MM = 105.99

m = n x MM
m = 0.030 x 105.99
m = 3.18 g (3sf)
</td>
<td>Generally, well answered.

Please show all your working, that included calculation for MM.

Some used the incorrect formula for moles calculation. You were told a volume and concentration. Some used n=m/MM please note this is for solids NOT solutions.</td>
</tr>
<tr>
<td>28b</td>
<td>
<table>
<tr><th>Criteria</th><th>Mark</th></tr>
<tr><td>Effect stated and impact explained</td><td>2</td></tr>
<tr><td>Relevant statement</td><td>1</td></tr>
</table>
</td>
<td>The concentration will be reduced as extra water is added and then some moles of Na_2CO_3 are removed when the scientist uses the pipette to remove some extra drops and as c = n x v the number will be lower than actual.</td>
<td>To get both marks you needed to state the effect on the concentration. This was lowered as a result of the additional water added.</td>
</tr>
</table>

<table>
<tr>
<td>28c</td>
<td>
<table>
<tr><th>Criteria</th><th>Mark</th></tr>
<tr><td>Writes balanced equation to get mole ration and Correctly calculates:
• Moles of Na_2CO_3 that reacts
• Moles of HCl using mole ratio
• Volume of HCl</td><td>4</td></tr>
<tr><td>As above but 1 error</td><td>3</td></tr>
<tr><td>As above but 2 errors</td><td>2</td></tr>
<tr><td>1 relevant calculation</td><td>1</td></tr>
</table>
</td>
<td>
$2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$

$n(Na_2CO_3) = 0.05 \times 0.025$
$= 0.00125$

Na_2CO_3 : HCl
1 : 2
$n(HCl) = 2 \times 0.00125$
$= 0.0025$

$v(HCl) = 0.0025 / 0.0890$
$= 0.0281$ L

Or can report to mL 28.1 mL

$n(Na_2CO_3) = 0.06 \times 0.025$
$= 0.0015$

Na_2CO_3 : HCl
1 : 2
$n(HCl) = 2 \times 0.0015$
$= 0.003$

$v(HCl) = 0.003 / 0.0890$
$= 0.0337$ L

Or can report to mL 33.7 mL
</td>
<td>Not well answered.
Many did not have a balanced equation and simply used

C1V1=C2V2

Please avoid using this method.

Best to do the calculation as shown the working.

If this method was used as a result of 1:1 mole ratio assumption with no equation you could only get a maximum of 2 marks.

If you had an equation with an error in balancing, error carried forward was applied.</td>
</tr>
<tr>
<td>29a</td>
<td>
<table>
<tr><th>Criteria</th><th>Mark</th></tr>
<tr><td>Correct time period</td><td>1</td></tr>
</table>
</td>
<td>0 -10 seconds</td>
<td>Well done across cohort, recognising the slope of the line between 0-10 seconds was the steepest</td>
</tr>
<tr>
<td>29b</td>
<td>
<table>
<tr><th>Criteria</th><th>Mark</th></tr>
<tr><td>Correct time period</td><td>1</td></tr>
</table>
</td>
<td>0.24 g of silver iodide

0.22 g of silver iodide</td>
<td>Well done across cohort</td>
</tr>
</table>

29 c

Criteria	Mark
Detailed explanation Referring linked to graph • Links concentration with chance of collisions • Links changes in concentration of reactants with graph	4
Detailed explanation missing 1 main point	3
Explanation lacking detail	2
Relevant statement	1

At the start of a reaction, (0-10s) when the concentrations of reactants are high, there is a higher chance of collisions between reactant particles. As reactants are consumed and converted into products, their concentrations decrease.

As the reaction progresses, the concentration of reactant particles decreases as they are used up to form the solid precipitate. This reduction in reactant concentration leads to less chance of successful collisions between reactant particles, resulting in a slower reaction rate.

Eventually, when most of the reactants have been consumed, the collision frequency becomes so low that the reaction practically stops as the rate of collisions drops to a very low level and stops and mass of silver iodide produced is constant as shown on graph from 70 seconds where the silver iodide mass formed is 0.24 g. (0.22g)

To get full marks here you needed to link the change in concentration of reactants with chance of successful collisions and link to the graph.

Some students started their answer with a definition of collision theory – well done.

You needed to point out that the reaction stopped as the reactants when the reactants were used up.

Some answers used molecules in their answer, in this case better to talk about ions. I didn't penalise for this but did point this out.

29 d

Criteria	Mark
Correctly calculates the concentration of NaI	3
Provides some correct calculations	2
One relevant step	1

m(AgI) formed = 0.24 g (from graph)

$NaI\ (aq) + AgNO_3\ (aq) \rightarrow AgI\ (s) + NaNO_3\ (aq)$

Ratio NaI : AgI is 1 : 1

n(NaI) = 0.24/234.77 = 0.001022227712

volume = 10 mL = 0.010 L

c=n/V
= 0.001022227712/0.010
= 0.10 mol/L
Hence initial conc of NaI is 0.10 mol/L

m(AgI) formed = 0.22 g (from graph)

$NaI\ (aq) + AgNO_3\ (aq) \rightarrow AgI\ (s) + NaNO_3\ (aq)$

n(NaI) = 0.22/234.77 = 0.0009370874

volume = 10 mL = 0.010 L

c=n/V
= 0.0009370874/0.010
= 0.09 mol/L
Hence initial conc of NaI is 0..094 mol/L

Many students didn't indicate what they were calculating. It is important to tell the marker this.

Also many students used 0.24g and the molar mass of NaI to calculate number of moles. 0.24 g was the mass of AgI.

Can only get 1 mark if 0.24g was used as mass of NaI when there is no reference to eqn and ratio

If moles of AgI was correctly calculated awards 2 marks

29 e

Criteria	Mark
Correctly calculates the concentration of remaining solution to 2sf	4
Provides substantially correct calculations	3
Provides some correct calculations	2
Provides some relevant information or working	1

$NaI\ (aq) + AgNO_3\ (aq) \rightarrow AgI\ (s) + NaNO_3\ (aq)$

Volume of each solution is 10 mL
Total V = 20 mL = 0.020 L

n(NaI) = 0.001022227712

$NaI : NaNO_3$

1 : 1

So, $n(NaNO_3) = 0.001022227712$

Hence concentration of $NaNO_3$ = 0.001022227712/0.020 = 0.051 mol/L
2 Sig fig

Volume of each solution is 10 mL
Total V = 20 mL = 0.020 L

n(NaI) = 0.0009370874

$NaI : NaNO_3$

1 : 1

So, $n(NaNO_3) = 0.0009370874$

Hence concentration of $NaNO_3$ = 0.0009370874/0.020 = 0.04685437 or 0.047 mol/L
2 Sig fig

Error carried forward for incorrect moles or concentration.
Most students struggled with this question

The total volume is 20 mL as 2 solutions of 10 mL each were added

2 significant figures was required