GESS Sec 4 Chemistry (6092) Preliminary Exams 2024
Suggested Solutions

PAPER 1

Question Number	*Key*	*Question Number*	*Key*
1	**A**	21	**B**
2	**B**	22	**A**
3	**B**	23	**D**
4	**C**	24	**D**
5	**B**	25	**B**
6	**B**	26	**A**
7	**C**	27	**B**
8	**D**	28	**A**
9	**A**	29	**A**
10	**D**	30	**B**
11	**A**	31	**D**
12	**A**	32	**C**
13	**C**	33	**D**
14	**A**	34	**B**
15	**A**	35	**B**
16	**C**	36	**C**
17	**D**	37	**D**
18	**A**	38	**D**
19	**A**	39	**B**
20	**C**	40	**D**

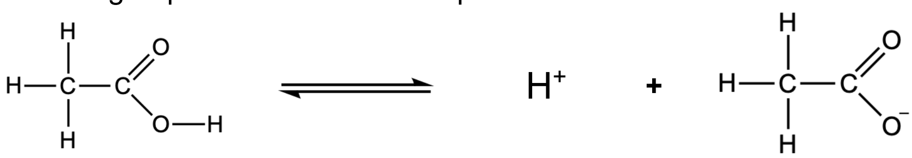
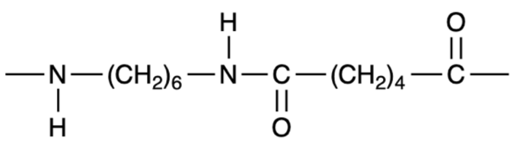
Question	Answer	Explanation
1	**A**	Option A is correct as the burette can measure variable volumes of a liquid in a titration. Option B is incorrect because the 0.24 dm^3 is equivalent to 240 cm^3 which exceeds the capacity of the gas syringe. Option D is incorrect as a pipette can only measure a fixed volume of a liquid depending on its size, in this case 25.0 cm^3.
2	**B**	Q has a lower R_f value than R as it travelled a shorter distance from the start line.
3	**B**	The mixture is heated using a water bath, hence any substance with a boiling point above 100 ºC (i.e. **C** & **D**) cannot be distilled. Substance **A** is a gas at room temperature.
4	**C**	The transition from (s) → (*l*) → (g) is endothermic as energy is absorbed to overcome forces of attraction between the particles.
5	**B**	A mixture of solid and liquid exists at the melting point/freezing point, which occurs at 50 ºC.
6	**B**	Since the ion has a charge of 3+, it means that Z would have lost 3 electrons, and is therefore in Group 13. Since the ion has 2 electron shells, Z must have had three electron shells in total and is hence in Period 3.
7	**C**	Sea water is a mixture; sodium chloride is a compound and chlorine is an element.
8	**D**	In graphite, each carbon atom is only bonded to three other carbon atoms, leaving one electron per carbon atom not involved in bonding. The electrons which are not involved in bonding are delocalised, acting as mobile charged carriers. Metals such as aluminium have a sea of delocalised electrons which act as mobile charged carriers. Ionic compounds conduct electricity due to the presence of mobile ions.
9	**A**	The electronic structure of oxygen is 2,6. It needs 2 more electrons to have a fully-filled valence shell. Each oxygen atom forms 2 covalent bonds. The electronic structure of chlorine is 2,8,7. It needs 1 more electron to have a fully-filled valence shell. Each chlorine atom forms 1 covalent bond. This results in a structure with the formula Cl_2O.
10	**D**	Both silicon and carbon are in Group 14, hence SiO_2 and diamond both have a giant covalent structure where the atoms around Si and C are in a tetrahedral arrangement, i.e. each Si and C atom forms 4 covalent bonds. For giant covalent structures, there are no intermolecular forces of attraction as all the atoms are joined via covalent bonds. Melting requires breaking these covalent bonds.
11	**A**	nO_2 = 500/24000 = 0.020833 mol 1 mol contains 6.02×10^{23} molecules. Hence, number of molecules = $0.020833 \times 6.02 \times 10^{23} = 1.254 \times 10^{22}$

<table>
<tr><td>12</td><td>A</td><td>The sum of the relative molecular masses of Mg atoms in a molecule of chlorophyll-a is $\frac{2.69}{100} \times 893$ = 24.02. Since the A_r of a Mg atom is 24, there is only one Mg atom.</td></tr>
<tr><td>13</td><td>C</td><td>concentration of saline in g/dm^3 = $\frac{0.9}{\frac{100}{1000}}$ = 9 g/dm^3
concentration of saline in mol/dm^3 = $\frac{9}{23+35.5}$ = 0.1538 mol/dm^3</td></tr>
<tr><td>14</td><td>A</td><td>nH_2 = $\frac{8}{2}$ = 4 mol
nO_2 = $\frac{8}{32}$ = 0.25 mol (limiting reactant)
nH_2O formed = 0.5 mol
mass of H_2O = 0.5 × 18 = 9 g</td></tr>
<tr><td>15</td><td>A</td><td>Quicklime (CaO) or slaked lime ($Ca(OH)_2$) are both used by farmers to neutralise the excess acids in the soil, raising the pH.</td></tr>
<tr><td>16</td><td>C</td><td>The pH at which the indicator changes colour must fall within the region of drastic pH change in the titration graph. This is where the ‘step’ occurs, in this case it spans the range of around pH 5 to 11.</td></tr>
<tr><td>17</td><td>D</td><td>Copper is an unreactive metal, hence it does not react with acids.
To prepare copper(II) sulfate, we add excess copper(II) oxide, copper(II) carbonate or copper(II) hydroxide to ensure all the acid is reacted. We then filter the mixture to remove the excess solid, collect the filtrate and carry out crystallisation on the filtrate.</td></tr>
<tr><td>18</td><td>A</td><td>Ammonia turns moist red litmus paper blue, while chlorine bleaches both blue and red litmus papers.</td></tr>
<tr><td>19</td><td>A</td><td>Y must be an acid since a gas is produced when reacted with a carbonate. Y also contains nitrate ions as ammonia gas is given off when the solution is warmed with aluminium and sodium hydroxide.</td></tr>
<tr><td>20</td><td>C</td><td>In the chapter of Acids and Bases, we learnt that alkalis dissociate in water to give OH^- ions:
$NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$
$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

We also know that most metal hydroxides are insoluble in water. Hence, the green precipitate is $Fe(OH)_2$. The green precipitate slowly turns reddish-brown in air (oxidation).

$4\ Fe(OH)_2(s) + O_2(g) + 2\ H_2O(l) \rightarrow 4\ Fe(OH)_3(s)$</td></tr>
<tr><td>21</td><td>B</td><td>CO acts as a reducing agent as it causes Fe_2O_3 to be reduced to Fe. This is seen in the oxidation state of iron decreasing from +3 in Fe_2O_3 to 0 in Fe.</td></tr>
<tr><td>22</td><td>A</td><td>
<table>
<tr><th></th><th>positive (+) electrode X</th><th>negative (–) electrode Y</th></tr>
<tr><td>Ions attracted</td><td>Br^-</td><td>Pb^{2+}</td></tr>
<tr><td>Half equation</td><td>$2Br^-(l) \rightarrow Br_2(g) + 2e^-$</td><td>$Pb^{2+}(l) + 2e^- \rightarrow Pb(l)$</td></tr>
<tr><td>Nature of reaction</td><td>Oxidation</td><td>Reduction</td></tr>
<tr><td>Anode or cathode?</td><td>Anode</td><td>Cathode</td></tr>
</table>
</td></tr>
</table>

		<table><tr><td>**Observation**</td><td>Effervescence of reddish-brown gas</td><td>Grey/silvery globules of molten lead metal float to the surface</td></tr><tr><td>**Overall reaction**</td><td colspan="2">$PbBr_2(l) \rightarrow Pb(l) + Br_2(g)$</td></tr></table>
23	**D**	In electroplating, the object to be electroplated is always placed at the cathode (negative electrode), so that reduction of cations at the cathode will result in a solid deposit/coating around the object. The anode (positive electrode) is the metal used for electroplating. Oxidation at the anode replenishes the electrolyte with the cations. anode: $Ag(s) \rightarrow Ag^+(aq) + e^-$ cathode: $Ag^+(aq) + e^- \rightarrow Ag(s)$
24	**D**	In a simple cell, the larger the difference in reactivity of the two metal electrodes, the greater the voltage. Hence the voltage of cell 1 < cell 2. In both cells, magnesium is the more reactive metal and hence undergoes oxidation: $Mg(s) \rightarrow Mg^{2+}(aq) + 2\ e^-$. Mg^{2+} ions enter the electrolyte, which does not result in a colour change. Electrons flow from the more reactive metal (magnesium) to the other electrode.
25	**B**	Trends going down Group 1: • Melting and boiling points decrease • Density increases • Reactivity increases
26	**A**	Statement 1 is true. Melting and boiling points increases down the group. Since X is a liquid, it must be Br_2. Y, being a solid, must be below X in the Periodic Table. Statement 2 is false. All Group 17 elements are diatomic, meaning they are diatomic molecules which consist of two atoms covalently bonded. Statement 3 is false. Reactivity decreases down the group. Y is less reactive than X. Hence Y cannot displace X from its solution.
27	**B**	The two properties are characteristic of transition metals. Option B is the only one where all examples are transition metals.
28	**A**	This is a question on sacrificial protection. In the presence of an acid, the more reactive metal is preferentially oxidised: $M(s) + 2\ H^+(aq) \rightarrow M^{2+}(aq) + H_2(g)$ Given that all beakers contain zinc, the beaker where Zn is least likely to be oxidised is where there is a more reactive metal present, i.e. Mg.
29	**A**	The more reactive the metal, the more thermally stable the compound and the harder it is to decompose the carbonate. Z is the most stable carbonate (Na_2CO_3) while Y is the least stable carbonate ($CuCO_3$).
30	**B**	Energy absorbed during bond breaking = 4BE(H–H) + BE(N–N) = 4(390) + 160 = 1720 kJ/mol Energy released during bond forming = BE(N≡N) + 2BE(H–H) = 945 + 2(436) = 1817 kJ/mol

		Enthalpy change = +1720 – 1817 = –97 kJ/mol
31	**D**	nO_2 = 4 mol mole ratio of $O_2 : e^-$ = 1:4 ne^- = 16 mol mole ratio of $e^- : H_2$ = 2:1 nH_2 = 8 mol Mass of H_2 = 8 × 2 = 16 g
32	**C**	Option A, B and D are incorrect as a lower temperature or different particle size will not change the yield. HC*l* is the limiting reactant. Hence to produce curve Q, a lower number of moles of HC*l* is used.
33	**D**	P represents the enthalpy change for the *backward* reaction. Q represents the enthalpy change for the *forward* reaction. R represents the activation energy for the *forward* reaction.
34	**B**	The temperature at the top of the column is lower. Smaller molecules with lower boiling points condense higher up the column. Hence, X has a lower boiling point range and consists of short chain hydrocarbons than Y.
35	**B**	In an addition reaction, the two bromine atoms are added across the double bond. They must be on <u>adjacent</u> carbon atoms.
36	**C**	Option C is the same molecule as it consists of a continuous chain of 5 carbon atoms.
37	**D**	A: Since the formation of an ester involves condensation of a carboxylic acid with ethanol, he M_r increases. B: The M_r of ethanoic acid is 60 while the M_r of ethanol is 46. C: The M_r of ethanol is 46 while the M_r of ethene is 28. D: The M_r of ethanol is 46 while the M_r of glucose is 180.
38	**D**	When a carboxylic acid dissociates, the O–H bond of the –COOH functional group is broken. The example shown below is for ethanoic acid.  $CH_3COOH(aq)$ ethanoic acid; hydrogen ion; $CH_3COO^-(aq)$ ethanoate ion
39	**B**	The structure of the repeating unit is:  Subtract the atoms that are lost in the condensation reaction. Therefore, the M_r is 116 + 146 – [1 + 1 + 16 + 1 + 16 + 1]
40	**D**	Under high temperature conditions in the car engine, nitrogen and oxygen in the air react to form oxides of nitrogen. In the catalytic converter, carbon monoxide is oxidised to carbon dioxide, oxides of nitrogen are reduced to nitrogen. $2\ NO(g) + 2\ CO(g) \rightarrow N_2(g) + 2\ CO_2(g)$

PAPER 2

1 **(a)** **A** sodium
B sulfur / silicon
C chlorine
D magnesium
E aluminium [5]

ALLOW symbol of element

(b)

element	undergone oxidation	undergone reduction	neither oxidised nor reduced
A	✓		
B			✓
C		✓	
D	✓		
E			✓

Any 2 correct = 1 m; all 5 correct = 3 m [3]

[Total: 8]

2 **(a)** the gases may be <u>passed through</u> anhydrous/fused calcium chloride / quicklime / <u>bubbled into/passed through</u> concentrated sulfuric acid

Note: Question asks 'how' therefore stating the chemical alone is not sufficient [1]

(b) **(i)** higher M_r, longer retention time / longer time taken for component to travel through the column [1]

(ii) shorter retention time [1]
(kinetic) energy of particles increase [1]
rate of diffusion increases [1] [3]

(c) solubility of solute in solvent / type of solvent / type of solute / type of paper [1]

[Total: 6]

3 **(a)** 2 [1]
weak acid undergoes partial dissociation / presence of undissociated HA [1]
low concentration of H^+ [1] [3]

(b) dibasic [1]
Should be represented as H_2A / H_2SO_4 dissociates to produce 2 H^+ ions for every A^{2-} [1] [2]

(c) No.
same moles of acid / H^+ ions [1] [1]

(d) add dilute nitric acid, then aqueous barium nitrate [1] [2]

white precipitate [1]
Note: not necessary to acidify since the unknown is sulfuric acid which does not contain carbonate ions.

[Total: 8]

4 **(a)** **(i)** ozone blocks UV / destruction leads to more UV radiation [1]
sunburns / skin cancer / premature aging / cataracts [1] [2]

(ii) $2\ O_3 \rightarrow 3\ O_2$ 1 m – formulae, 1 m – balanced [2]

(iii) remains chemically unchanged [1] [1]

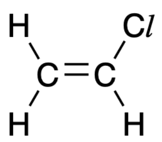
(iv)

Table 4.1

isotope	^{35}Cl	^{37}Cl
number of electrons	17	17
number of neutrons	18	20
number of protons	17	17

Any 3 = 1 m [2]

(b) **(i)**



[1]

(ii)

	Any one from:
Land pollution	filling landfill sites / shortage of landfill sites / visual pollution
Water pollution	gets stuck in animals digestive system / animals get stuck in the plastic / mistake plastic items for food / stops light getting to organisms in sea (must mention an effect on animals)
Air pollution	release poisonous gases when burnt NOT carbon monoxide, sulfur dioxide. If gas named has to be a correct one i.e. HC*l*

[1]

(iii) conserving crude oil / saving energy / reduce carbon emissions [1]
REJECT: cheaper [1]

[Total: 10]

5 **(a)** gradient <u>steeper</u> for graph for strontium therefore a <u>greater volume of gas produced per unit time</u> [1] **Note:** steeper graph alone is insufficient to earn full credit as students need to explain what is understood by 'steeper'. [1]

(i) Total volume = 53 cm^3
Time taken for reaction to be complete = 65 s (allow $\pm$1)
Average rate = total volume / total time = 53/65 = **0.815 cm^3/s** (OR 0.828, 0.803) [1] [1]

(ii) the line was still going up / the line was still rising / not horizontal / gradient not zero / gradient still positive
REJECT: not constant [1]

(b) $Sr + 2\,H_2O \rightarrow Sr(OH)_2 + H_2$ [2] 1 m – formulae, 1 m – balanced

strontium hydroxide is an alkali / alkaline / base / contains OH^- [1] [3]

(c) **electrolysis of an aqueous solution:**
Answer must compare reactivity + state what is discharged + what is formed [1]
e.g. hydrogen below strontium in reactivity, H^+ preferentially discharged to form H_2

reduction of the oxide by carbon:
Answer must compare reactivity + state the outcome [1]
e.g. Sr more reactive than carbon therefore carbon cannot reduce strontium oxide/ carbon doesn't displace strontium [1] [2]

[Total: 8]

6 **(a)** **Any one of**
- <u>cracking</u> of <u>alkanes / hydrocarbon</u> (using heat / catalyst)
  ALLOW: cracking of crude oil
- <u>electrolysis</u> of <u>water</u> (H_2 obtained at cathode)
- <u>steam</u> reforming / reacting <u>alkane</u> with steam using <u>heat / catalyst</u> (not in syllabus) [1]

(b) electronic structure is 2.5 / 5 valence electrons [1]
<u>needs three electrons</u> for <u>fully-filled/complete valence shell</u> [1] (therefore shares three electrons, one to each hydrogen atom) [2]

(c) as temperature increases, yield decreases ORA [1] [1]

(d) **(i)**
- increases rate of reaction [1]
- molecules closer together / more reacting particles per unit volume [1]
- frequency of effective collisions increases [1] [3]

(ii) **Any one of**
- increases yield of NH_3 / produces higher % of NH_3 [1] [1]

- lower temperature can be used to achieve comparable rate thus saving energy [1]

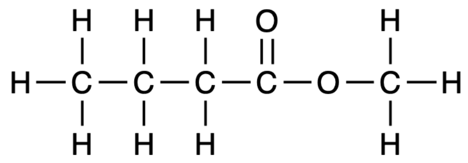
(iii) **Any one of**

- safety risk / risk of explosion [1]
- high cost, with link to construction / materials to withstand pressure [1] [1]

(e) recycled / sent over catalyst again [1] ALLOW used again [1]

[Total: 10]

7 **(a)**



[1]

(b) to <u>cool</u> and <u>condense</u> vapours / minimise loss of volatile chemicals during heating
ALLOW: prevent vapours from escaping [1]

(c) immiscible (ALLOW: insoluble / do not mix) [1]

(d)

M1	no. of moles of methanol = 2/32 = **0.0625 mol** [1]
M2	In an esterification reaction, the stoichiometry is 1:1:1:1 actual yield of methyl butanoate (in mol) = **0.009804 mol** theoretical yield of methyl butanoate (in moles) = **0.0625 mol** [1] **OR** actual yield of methyl butanoate (in g) = **1.0 g** theoretical yield of methyl butanoate (in g) = **6.375 g** [1]
M3	percentage yield = $\frac{1.0}{6.375} \times 100\%$ = 15.686% ≈ **15.7% (3 s.f.)** [1] **OR** percentage yield = $\frac{0.009804}{0.0625} \times 100\%$ ≈ **15.7% (3 s.f.)** [1]

[3]

(e) **similarity (any one) [1]**

- both involve formation of ester linkage
- both involve loss of water
- both undergo condensation polymerisation between a hydroxyl and carboxyl group (REJECT alcohol and carboxylic acid)
- both require heat / catalyst for formation

difference (any one) [1]

methyl butanoate	polyethylene terephthalate
joining two molecules	joining many molecules (monomers)
between alcohol and carboxylic acid	between diol and dicarboxylic acid
no repeating unit	has repeating units

[2]

loss of one water molecule	loss of many water molecules

[Total: 8]

8 **(a)** At pH 8.2, $CO_2(aq) < CO_3^{2-}(aq) < HCO_3^-(aq)$ (ignore if state symbols are not written) [1]

(b) $2\ H^+(aq) + 2\ e^- \rightarrow H_2(g)$ [1] (ignore if state symbols are not written)

H^+ preferentially discharged (to form H_2) AND $[H^+]$ decreases / $[OH^-]$ increases [1]
ALLOW: 'selectively' in place of 'preferentially'
ALLOW: 'reduced' in place of 'discharged' [2]

(c) When pH increases, concentration of CO_3^{2-} increases / $CO_2(aq)$ and/or HCO_3^- converted to CO_3^{2-} / more CO_3^{2-} formed [1]

Ca^{2+} and Mg^{2+} react with CO_3^{2-} to form $CaCO_3$ and $MgCO_3$ [1]
Allow if expressed in the form of ionic equations. [2]

(d) Cl_2 / chlorine [1]

High concentration of Cl^- relative to other anions AND Cl^- preferentially oxidised / selectively discharged compared to OH^- [1] [2]

(e) In forsterite, the formula of the anion is SiO_4^{4-}. $n = 1$ and $x = 0$

In anorthite, the formula of the anion is $Si_2O_8^{8-}$. $n = 2$ and $x = 0$ [2]

(f)

	Feature of Equatic-1	Impact on environmental sustainability
Positive	H_2 when burnt/used as fuel, water is the only product;	eliminating any further CO_2 emissions / reduce reliance on fossil fuels / relate to competing uses of crude oil / renewable
	CO_2 removed from seawater by precipitation in the form of solid metal carbonates CO_2 removed from environment by bubbling air through (immobilised in the form of dissolved HCO_3^-)	Re-establish levels / reduce carbon content in ocean / counteracts ocean acidification / restore capacity of ocean to take up CO_2 / increase pH of water / reduces the overall rate at which humans are adding CO_2 to the atmosphere
	carbonates used for construction	conserving (finite) resources
Negative	electrolysis is energy intensive	may require fossil fuels / add more CO_2 to the environment / however it is possible to use solar energy
	negligible amount of CO_2 removed compared to annual emissions	One plant is not enough / many plants need to be built to remove enough CO_2 to achieve net zero

[3]

		may not be feasible in terms of construction cost and land use

Any 2 boxes = 1 m (max 3 m)

[Total: 12]

9 (a) Any two

- NH_4^+ (& NO_3^-) ions have single positive and negative charges
- Calcium ion has a +2 charge which is not represented in the diagram
- There is a 1:1 ratio for ammonium nitrate
- There needs to be a 1:2 ratio for calcium nitrate [2]

(b) Any one

- nitrate / polyatomic ions contain multiple atoms
- ions are not spherical
- vibration / movement of ions is not shown
- there are many more ions in a real ionic compound
- only 2D shown but ions in an ionic compound are arranged in 3D [1]

(c)

	Each marking point worth 1 m (max 1 per row)
M1 (magnitude)	• ΔH larger magnitude / value for calcium nitrate / larger difference in energy between reactant and products ORA (BOD: larger energy change)
M2 (ΔH)	• $\Delta H < 0$ / exothermic for $Ca(NO_3)_2$ but $\Delta H > 0$ / endothermic for NH_4NO_3
M3 (explanation for ΔH)	overall exothermic for $Ca(NO_3)_2$ because more energy released than absorbed AND overall endothermic for NH_4NO_3 because more energy because more energy absorbed than released ALLOW heat energy, but NOT heat REJECT: used / required / needed
M4 (explanation for difference in magnitude)	Bigger difference in amount of energy absorbed for bond breaking and amount of energy released in bond forming for $Ca(NO_3)_2$, compared to NH_4NO_3

[4]

(d) (i) add excess $CaCO_3$ to nitric acid [1]
stir until no more effervescence
filter to remove residue / obtain filtrate [1] [2]

(ii) aqueous ammonia / ammonium carbonate + nitric acid [1] [1]

[Total: 10]

10 **(a)** **(i)** $C_{25}H_{51}$ [1] [1]

(ii) The (C and H) <u>atoms</u> are already in the <u>simplest ratio</u> [1]
ALLOW they have odd numbers of carbon atoms / prime numbers of carbon atoms / can't divide by 2
ALLOW formula cannot be simplified / cannot cancel down [1]

(b) simple molecular structure[1]

little energy needed to overcome weak intermolecular forces of attraction [1] [2]

(c)

	Each marking point worth 1 m (max 1 per row)
M1 (similar structure)	• are hydrocarbons / only contain carbon and hydrogen • are saturated/contain all single bonds/do not have any functional groups • covalent bonds / have (weak) intermolecular forces between molecules • each molecule differs from the last by CH_2
M2 (same general formula)	• C_nH_{2n+2}
M3 (similar chemical properties)	• similar (REJECT: same) chemical property / give e.g. undergo combustion/flammable/are generally unreactive/undergo substitution reaction
M4 (trend in physical properties)	• example of physical property which changes down the series (e.g. m.p./b.p. increase, less volatile/more dense/less flammable) • states show a trend in their change from gas (to liquid) to solid

[4]

(d)

	Each marking point worth 1 m (max 1 per row)
M1 (profitability)	• <u>higher demand / meet demand</u> for smaller molecules ALLOW: more valuable *no marks for stating the use of small molecules without idea of matching demand*
M2 (environment)	• <u>reduce waste</u> / fully utilise crude oil by converting excess of large molecules to smaller, more useful ones • <u>reduce pollution</u> as smaller molecules burn more efficiently / cleanly as fuels

[2]

[Total: 10]

PAPER 3

1 **(a)** • Weigh the vial with **X**. Record this mass.

9.07 g

mass of container with **X** = ... g

Results

time/min	0	1	2	3	4	5	6	7	8
temperature/ºC	**30.0**	**30.0**	**30.0**		**37.0**	**36.5**	**36.0**	**35.5**	**35.0**

• Reweigh the container with any residual solid. Record this mass.

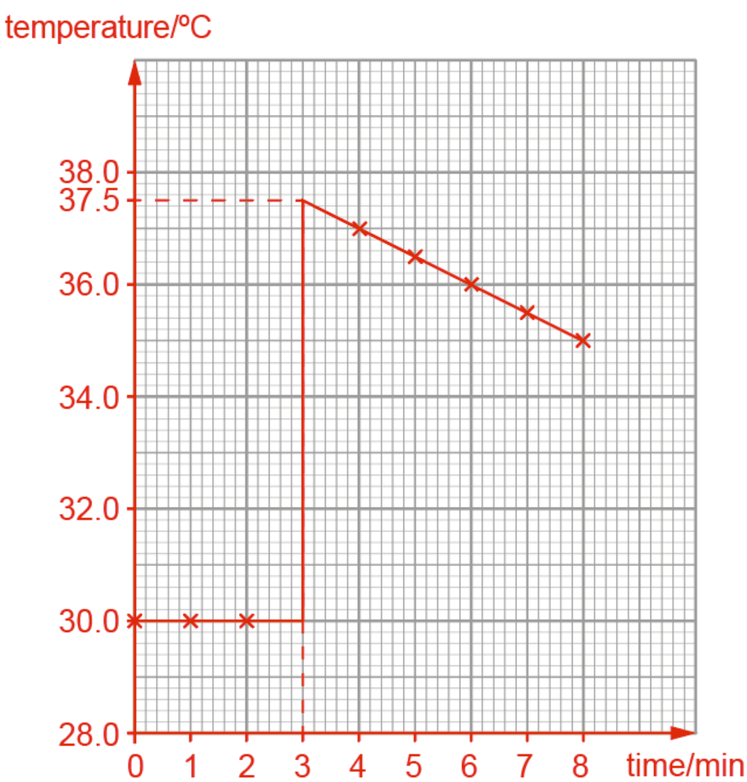
6.10 g

mass of container with residual **X** = ... g

[MMO] first 3 readings within ±1ºC and last 5 readings show a falling trend [1]
[MMO] ΔT from T at 2 minutes to T_{max} from table is within ±2ºC of supervisor. [1]
[PDO] balance readings to 2 d.p. AND temperature to .5 or .0 ºC [1]

[3]

(b) **(i)**



Correct

- **P**lots [1]
- **A**xis labelled with units and values, following precision of data in candidate's table, allow ecf from table [1]
- **S**cale [1]
- **L**ines [1] Two straight lines of best fit extrapolated to vertical line at 3 minutes.

[4]

(ii) ΔT read to within half a small square to the precision of the grid AND nearest 0.5 °C [1]
*example: 37.5 – 30.0 = **7.5 °C*** [1]

(c) **(i)** heat released = 25 × **(b)(ii)** × 4.2 [1]
*example: 25 × **7.5** × 4.2 = 787.5 ≈ **788 J*** [1]

(ii) no. of moles of $Na_2CO_3 = \frac{\text{(c)(i)}}{40000}$ [1]
example: 787.5 ÷ 40000 = 0.0196875 mol

mass of Na_2CO_3 = moles × 106 [1]
*example: 0.0196875 × 106 = 2.08688 ≈ **2.09 g*** [2]

(iii) mass of **X** used = $m_f - m_i$ in **(a)**
% Na_2CO_3 $\frac{\text{(c)(ii)}}{\text{mass of } \mathbf{X} \text{ used}}$ [1]

Appropriate significant figures in final answers in **(c)**, allow 2 or 3 s.f. [1]
*example: [2.08688 ÷ (9.07–6.10 g)] × 100% = 70.265% ≈ **70.3 %*** [2]

(d) the impurity does not react with acid / **Y** OR impurities are not alkaline [1] [1]

(e) idea that heat lost is compensated for by cooling curve plotted [1]
Example: Due to <u>heat loss</u> to the surroundings, the highest temperature measured will be lower than it should be. <u>Using the graph</u> <u>takes into account</u> the temperature decrease to extrapolate a value for the theoretical maximum in the temperature, and is therefore more accurate. [1]

(f) (The student used) <u>fewer moles</u> / less amount of <u>carbonate</u> [1]

(The temperature increase is less and hence calculated) <u>enthalpy</u> change would be <u>less exothermic</u> / <u>ΔH</u> is <u>less negative</u>. [1] [2]

[Total: 17]

2 (a) Result

Titration number	**1**	**2**
Final burette reading/cm^3	19.90	40.00
Initial burette reading/cm^3	0.00	20.00
Volume of **P** used/cm^3	19.90	20.00
Best readings	✓	✓

PDO
H – Headings/Presentation of results [1]
B – Burette readings to 0.05 cm^3 [1]

MMO
C – Concordance within 0.20 cm^3 [1]
A – Accuracy within 0.20 cm^3 [2];
within 0.30 cm^3 [1]

[5]

(b) titre values identified in table by a tick or in a calculation **AND** 2 d.p. with units [1]
marks for missing units will be deducted in **(c)(iii)**

[1]

(c) (i) $\frac{0.0200 \times \textbf{(b)}}{1000}$ [1]

example: $\frac{0.0200 \times \mathbf{19.95}}{1000}$ = ***0.000399 mol***

[1]

(ii) $\frac{0.0795 \times 25.0}{1000}$ [1]
= 0.0019875 mol
≈ 0.00199 mol (3 s.f.) [1]

(iii) $\frac{\text{answer to \textbf{(ii)}}}{\text{answer to \textbf{(i)}}}$ [1] *Allow ecf*

Appropriate significant figures in final answers in **(c)**, 3 s.f. [1]

example: $\frac{0.0019875}{0.00399}$ = ***4.98 mol*** [2]

(iv) Equation 1 as ratio of $KMnO_4$: **M**SO_4 1:5
AND reference to answer in **(c)(iii)** [1]
Allow ecf

example: From the calculations, 1 mol of $KMnO_4$ reacts with 4.98 mol of ***M****SO_4. This is consistent with equation 1, where the mole ratio of $KMnO_4$:* ***M****SO_4 is 1 : 5.* [1]

(d) when some M^{2+} ions are oxidised, moles / amount of $\mathbf{M}^{2+}$ in flask is smaller [1]

moles / amount / volume of MnO_4^- / value in **(c)(i)** smaller [1]
(reject: concentration)

$\frac{\text{answer to } \mathbf{(ii)}}{\text{answer to } \mathbf{(i)}}$ OR value in **(c)(iii)** will be larger [1] [3]

(e)

test	observations
Test 1 Put about 2 cm depth of **R**(aq) in a test-tube. Then add a 2 to 3 drops of Universal Indicator solution.	Red solution [1] [1]
Test 2 Put about 2 cm depth of **R**(aq) in a test-tube. Add an equal volume of **Y**. Then add 2 to 3 drops of solution **P**.	Purple solution turns colourless / decolourises [1] [1]

(f) **(i)** From your observations in part **(e)**, deduce the identify of a cation in **R**(aq).

Explain your deduction using evidence from your observations.

cation is H^+

explanation In **<u>Test 1</u>**, Universal indicator turns **<u>red</u>**, the solution is **<u>acidic</u>** / is an acid / pH < 7.

[1]

(ii) The role played by **R**(aq) may be either that of an oxidising agent or of a reducing agent.

Deduce the role played by **R**(aq) in Test 2.

Explain your deduction using evidence from your observations.

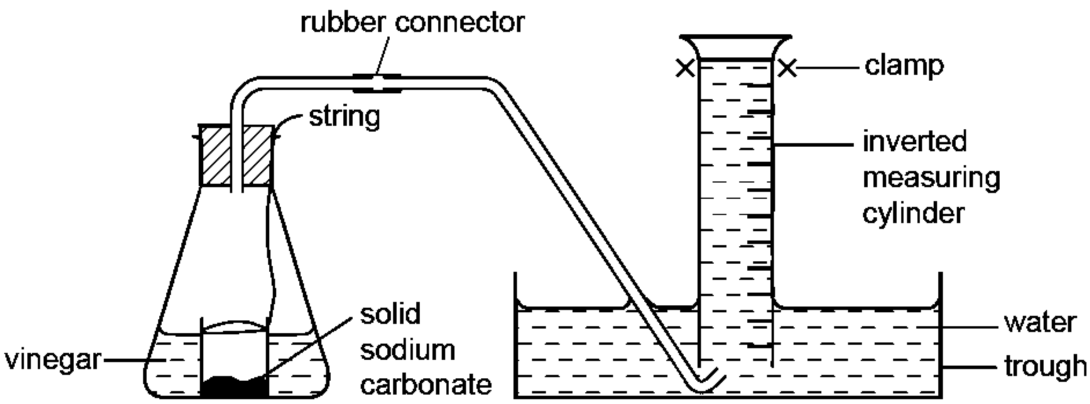
role played by **R** reducing agent

explanation In **<u>Test 2</u>**, when **P** / $KMnO_4$ was added, the **<u>purple solution turns colourless</u>** because **<u>R caused P / KMnO₄ to undergo reduction</u>** to Mn^{2+} ions. [1]

[Total: 18]

3

	Marking point	Comments
M1	**Measuring cylinder** to collect gas by displacement of water. **Electronic balance** to weigh Na_2CO_3	**ALLOW:** Drawn or stated in procedure **REJECT:** Gas jar/test-tube/gas syringe.
M2	Measure **stated volume** of vinegar using **measuring cylinder / burette / pipette**. Specified mass of Na_2CO_3 Mentions that reagents are combined and flask is stoppered.	**ALLOW:** Drawn or stated in procedure
M3	Record total/final **volume of CO_2** and shows **how to calculate nCO_2**. using 1 mol = 24 dm^3	**Reject:** "Record the volume of gas collected after x mins" – this is not a question on rate of reaction. BOD: if 'total/final' not mentioned
M4	Explains how to apply 1:2 mole ratio is used and use moles to determine concentration of ethanoic acid.	
M5	**Assumption:** Na_2CO_3(s) is in excess / acid fully reacted OR volume of CO_2 collected dissolved is negligible	



1. Measure <u>25 cm^3</u> **(M2)** of <u>vinegar</u> using a <u>measuring cylinder</u> **(M1)** and pour the solution into a conical flask.

2. Weigh <u>5 g</u> **(M2)** of solid <u>sodium carbonate</u> (in excess) using an <u>electronic balance</u> **(M1)** and place the solid into a small vial. Carefully lower the vial into the conical flask, ensuring the chemicals do not mix.

3. Set up the apparatus as shown above. [5]

4. Pull the string to allow the solid carbonate to react completely (**M5**) with the vinegar. ALLOW: add carbonate and stopper the flask immediately (**M2**).

5. Record the total volume of CO_2, **V** cm^3 collected in the measuring cylinder when reaction is complete (no more effervescence).

6. Calculate the number of moles of CO_2, **n** = **V** cm^3 / 24000 cm^3.

M3

7. Using the mole ratio CH_3COOH : CO_2 = 2:1, number of moles of CH_3COOH = 2**n** mol

8. Concentration of CH_3COOH = moles/volume = 2**n** mol / 0.025 dm^3

M4

CONFIDENTIAL INSTRUCTIONS

[QUESTION 1]

Apparatus for each candidate

No.	Qty	Items
1	1	25 cm^3 measuring cylinder
2	1	foamed plastic (polystyrene) cup approximately 150 cm^3
3	1	250 cm^3 beaker
4	1	thermometer (–10 °C to +110 °C at 1 °C)
5	1	stopwatch

Chemicals needed

No.	Label	Per candidate	Identity	Preparation
1	**X**	3.0 ± 0.1 g	mixture of **anhydrous** sodium carbonate and sodium chloride	Mix 2 g Na_2CO_3 and 1 g $NaCl$ (ratio 2 : 1 by mass), supplied in a stoppered vial. The solids should be well mixed.
2	**Y**	100 cm^3 (can combine with Q2)	1.0 mol/dm^3 sulfuric acid	Stock solution

Electronic balance (weighing stations) – to be placed around the lab

[QUESTION 2]

Apparatus for each candidate

No.	Qty	Items
1	2	conical flask
2	1	50 cm^3 burette
3	1	25 cm^3 pipette
4	1	pipette filter
5	1	funnel (for filling burette)
6	1	white tile
7	1	burette clamp and stand
8	1	25 cm^3 measuring cylinder
9	1	wash bottle with deionised water
10	2	test-tubes
11	1	test-tube holder
12	1	dropper

Chemicals needed

No.	Label	Per candidate	Identity	Preparation
1	**P**	150 cm^3	0.0200 mol/dm^3 potassium manganate(VII) solution	Dissolve 3.16 g of $KMnO_4$ in each dm^3 of solution.
2	**Q**	150 cm^3	0.0795 mol/dm^3 ammonium iron(II) sulfate solution	Dissolve 31.2 g of $(NH_4)_2Fe(SO_4)_2 \bullet 6H_2O$ (MW = 392) in 150 cm^3 of 1.0 mol/dm^3 sulfuric acid with continuous stirring. After all the solid has dissolved, make up to 1 dm^3 with deionised water.
3	**R**	1 g	ascorbic acid	In stoppered boiling tube
4	**Universal indicator**		Universal indicator	–
5	**Y**	100 cm^3	1.0 mol/dm^3 sulfuric acid	Stock solution