(a) (i) $140 \times 10^3 \times (0.00412) = (100) (4.18) (\Delta T)$

The temperature change of **1.38°C** is too small and (experimental) results would be very inaccurate.

(ii) Hence, write a detailed plan to verify the enthalpy change of reaction between magnesium and sulfuric acid, ΔH_1 .

Your plan should include the following:

- Justification of the mass of Mg turnings to be used
- Tabulation of raw data
- Brief description of how the data can be used to determine the enthalpy change of reaction

[6]

Justification of mass to be used

 $140 \times 10^3 \times (m/24.3) = (100) (4.18) (7)$ m = 0.508 g (any suitable mass to achieve a ΔT of 7 °C to 10 °C)

Procedure

- 1) Using a <u>100 cm³ measuring cylinder</u>, measure out <u>100 cm³ of sulfuric acid</u> into the styrofoam cup supported in a 250 cm³ beaker.
- 2) <u>Measure</u> and <u>record</u> the <u>initial temperature</u> of the solution.
- 3) <u>Weigh accurately 0.510 g</u> of Mg turnings in <u>a clean dry weighing bottle</u> using <u>a mass balance</u>.
- 4) Carefully transfer the Mg turnings into the cup, stir.
- 5) <u>Measure</u> and <u>record</u> the <u>highest temperature</u> reached.
- 6) <u>Re-weigh</u> the weighing bottle which may contain some residual Mg turnings; <u>record</u> the <u>actual mass</u> of solid sample used.

Tabulation of Data

Mass of weighing bottle and Mg turnings / g	
Mass of weighing bottle + residual solid after transfer / g	
Mass of Mg turnings used / g	Μ

Initial temperature of solution / °C	
Highest temperature of solution / °C	
Change in temperature, $\Delta T / °C$	

Treatment of Data

 $|\Delta H_1| \times M / 24.3 = 100 \times 4.18 \times \Delta T / 1000$ $\Delta H_1 = -(0.418)(24.3)(\Delta T) / M \text{ kJ mol}^{-1}$ (b)(i) Is the energy change when 1 mole of MgO (s) is formed from its elements, Mg (s) and O₂ (g) under standard conditions



$$\Delta H_{\rm f} = -602 \text{ kJ mol}^{-1}$$

2(a)

Step I: Nucleophilic Addition ; Step II: Hydrolysis

(b)



(c) Acts as a solvent

- (d)(i) (Strong) covalent bonds in organic molecules or the strong C-I bond must be broken.
- (ii) No of moles of pentan-2-one = 6 x 0.814 /86 = 0.05679 No of moles of Mg = 1.50 / 24.3 = 0.0617 Grignard reagent is in excess.



(1	F)
· ·	1

(i) (ii)	water saturated sodium hydrogencarbonate	Mg(OH)I /MgCl/MgI HCl
(iii)	sodium thiosulfate	lodine
(iv)	saturated sodium chloride	Water

(g) Transfer the diethylether layer into a distilling flask fitted with an air condenser and carry out distillation by boiling over temperature range from 141 °C to 145 °C.

3 (ai) 1

$$[Cl^{-}] = \frac{1.00 \times 10^{-3}}{\frac{10}{1000}} = \frac{0.100 \text{ mol dm}^{-3}}{1000}$$

$$[Ag^+] = \frac{K_{sp}}{[Cl^-]} = \frac{2.02 \times 10^{-10}}{0.100} = \frac{2.02 \times 10^{-9} \text{ mol dm}^{-3}}{0.100}$$

2
$$K_c = \frac{0.10}{2.02? \ 0^9 \text{II} NH_3]^2} = 1.50 \times 10^7$$

 $[NH_3]$ at equilbrium = 1.82 mol dm⁻³

No. of mol of NH_3 for complexation = = 2.00 x 10^{-3}

Total mol of NH₃ = 0.0182 + 2.00 x 10⁻³
[NH₃]_{total} =
$$\frac{0.0202}{\frac{10}{1000}}$$
 = 2.02 mol dm⁻³

(ii)

- **1** $\Delta G^{\theta}_{ppt} = 2.303 \times 8.31 \times 298 \times \lg 3.01 \times 10^{-12} = --65.7 \text{ kJ mol}^{-1}$
- 2 Precipitation is feasible hence, Ag₂CrO₄ is insoluble in water
- **(bi)** $[Ag^+] (0.5) = 2.02 \times 10^{-3}$

 $[Ag^+] = \frac{4.04 \times 10^{-10} \text{ mol dm}^{-3}}{10^{-10} \text{ mol dm}^{-3}}$

- (ii) $E = 0.80 + 0.059 \text{ lg } 4.04 \text{ x } 10^{-10} = +0.25 \text{ V}$
- (iii) KCl (aq) dissociates in water to form oppositely charged ions to maintain electrical neutrality *or* KCl (aq) is acting like a salt bridge since it dissociates in water to form oppositely charged ions.
- (ci) NaBr or sodium bromide
- (ii) $2 \text{HBr} + H_2SO_4 \rightarrow Br_2 + SO_2 + 2H_2O$ or conc H_3PO_4 is not an oxidising agent
- (iii) Disproportionation : $6 \text{ OH}^- + 3 \text{ Br}_2 \rightarrow 5 \text{ Br}^- + \text{BrO}_3^- + 3 \text{ H}_2\text{O}$
- (iv) Bond energies are 431, 366 and 299 kJ mol⁻¹ respectively. Bond strength of H–X decreases hence bond dissociation energy decreases. Hence, thermal stability of the HX decreases down the group.
- **4 (ai)** The dispersant can form hydrogen bonds with water molecules. The hydrophobic groups form weak Van der Waals' forces of attraction with the oil droplets.
 - (ii)



(bi) For reaction II: The electron withdrawing C=O group on the dienophile causes it to be more electron-deficient, thus making the dienophile a stronger electrophile. Hence, rxn is faster. For reaction I: The electron donating alkyl group on the dienophile causes it to be less electron-deficient, thus making the dineophile a weaker electrophile.



- (ci) Order of reaction wrt $CH_2=C(CH_3)CH=CH_2$ (or isoprene) is 1.
- (ii) Rate = $k[CH_2=C(CH_3)CH=CH_2][Cl_2]$
- (iii) Product F
- (iv)







(d) Step 1: Add dilute H₂SO₄, KMnO₄, heat to each compound separately Step 2: Add aq I₂, (excess) NaOH, heat to the reaction products

Observations: Yellow precipitate will be formed for compound E but not F

- **5(ai)** Dilute or aq HCl (or dilute H₂SO₄)
- (ii) Br_2 in CCl_4 (or aq. Br_2), r.t.p.
- (iii) H₂ with Ni catalyst at high temperature and pressure



- (c) For acyl bromide. the electron deficient carbonyl carbon in –COBr is bonded to two electronegative atoms.Hence, –COBr group is most susceptible to nucleophilic attack, thus it is most reactive. For aryl bromide, the p-orbital of the bromine atom interacts with the π electron cloud of the benzene ring.This strengthens the C-Br bond thus, rendering nucleophile substitution difficult hence least reactive.
- (d) Add dilute HCl to each compound and heat .Distill the products and add aqueous Na_2CO_3 to each mixture. Gas evolved forms a white ppt with $Ca(OH)_2$.
- 6(a) $[Cr(H_2O)_6]^{3+} + 3 OH^-$ Cr(OH)₃ + 6 H₂O or Cr(H₂O)₆]³⁺ + 3 OH⁻ Cr(OH)₃(H₂O)₃ + 3 H₂O

 $[Cr(H_2O)_6]^{3+} + 6 OH^$ $r(OH)_6]^{3-} + 6 H_2O$ $r(OH)_3(H_2O)_3 + 3 OH^$ $r(OH)_6]^{3-} + 3 H_2O$

- **(b)** $Cr_2O_3 + 3C + 3Cl_2 \rightarrow 2CrCl_3 + 3CO$
- (c) <mark>6</mark>
- (d) $[Cr(H_2O)_6]^{2+}$

(ei) Ligand exchange

(ii)



- (f) Cr³⁺ has partially filled 3d orbitals. The d orbitals are split into two groups via d-d splitting. d-d transition occurs where d e's are promoted to the higher d orbital During the transition, the d electron absorbs wavelength from the yellow region of light and emits the remaining wavelength which appears as purple color.
- (g) 4.90 = $\sqrt{n(n+2)}$; n = -6 (rejected) or <u>n=4</u>

High Spin State for Cr²⁺



- (hi) It is harder/more difficult to reduce the Cr³⁺ by adding an electron to an anion/negatively charged complex.
- (ii) Accept : $E^{e} = < -0.41V$