

Mark Scheme - C1.3 Chemical Calculations

- 1.
- (a) (i) $2\text{C(s)} + 3\text{H}_2\text{(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{C}_2\text{H}_5\text{OH(l)}$ (state symbols needed) [1]
 C(s) allowed as C(gr) or C(graphite) [1]
- (ii) (if these elements were reacted together) other products would form/
 carbon does not react with hydrogen **and** oxygen under standard conditions [1]
- (b) (i) energy = $100 \times 4.2 \times 54 = 22680$ [1]
- (ii) moles ethanol = $0.81/46 = 0.0176$ (1)
 energy change = $\frac{22.68}{0.0176}$ $\Delta\text{H} = -1290$ (1)
 -ve sign and correct to 3 sf (1) [3]
- (c) internet value numerically larger (1)
 heat losses / incomplete combustion / thermal capacity of calorimeter ignored (1) no credit for energy loss [2]
- (d) (i) $\text{C}_3\text{H}_7\text{OH} + 4\frac{1}{2}\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$ (ignore state symbols) [1]
- (ii) negative enthalpy change means energy in bonds broken is less than that in bonds made [1]
- (iii) more bonds broken and made in propanol and therefore more energy released [1]
- (e) any 4 from:
 both conserve carbon / non-renewable fuel sources / fossil fuels / use renewable sources
 (these gas / liquid) suitable for different uses e.g. ethanol to fuel cars
 atom economy gasification is less (some C lost as CO_2) / CO_2 produced in gasification is a greenhouse gas
 CO is toxic
 gasification at high temperature / enzymes need low temperature
 enzyme approach therefore saves fuel / gasification needs more energy [4]
 3 max if any reference to destruction of ozone layer
 QWC [2]
 The candidate has selected a form and style of writing that is appropriate to purpose and complexity of the subject matter (1)
 Answer has suitable structure (1)

Total [17]

2.

(a)

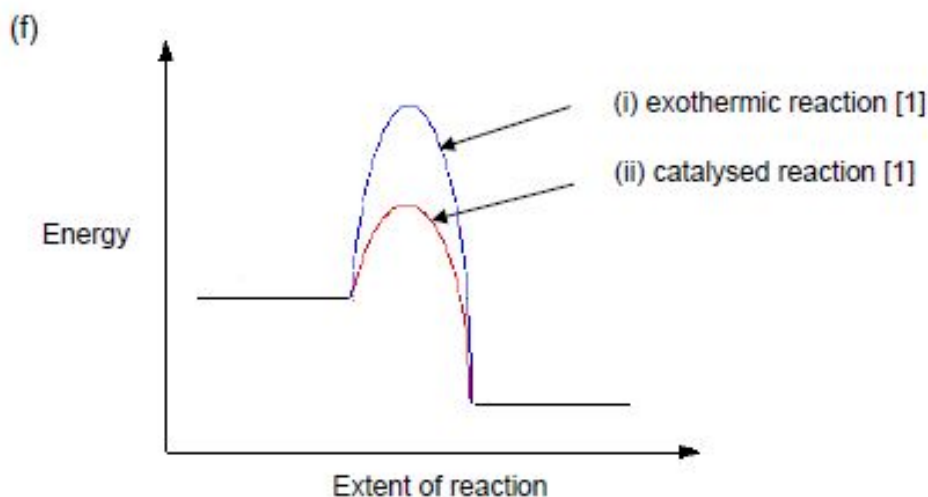
	1	2	3	4
<i>Volume used / cm³</i>	20.75	20.20	20.10	20.30

[1]

(b) 20.20 cm³

[1]

3. (a) Low temperature (1)
As temperature is decreased equilibrium moves in exothermic direction. (1)
- High pressure (1)
As pressure is increased equilibrium moves towards side with smaller number of gas moles (1) [4]
- QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate [1]
- (b) $\Delta H_{\text{reaction}} = \Delta H_f \text{ products} - \Delta H_f \text{ reactants}$ (1)
 $-46 = \Delta H_f \text{ ethanol} - (52.3 - 242)$
 $\Delta H_f \text{ ethanol} = -46 - 189.7$ (1)
 $\Delta H_f \text{ ethanol} = -235.7 \text{ kJ mol}^{-1}$ (1) [3]
- (c) Bonds broken = $1648 + 612 + 926 = 3186 \text{ kJ mol}^{-1}$ (1)
 Bonds formed = $2060 + 348 + 360 + 463 = 3231 \text{ kJ mol}^{-1}$ (1)
 $\Delta H_{\text{reaction}} = 3186 - 3231 = -45 \text{ kJ mol}^{-1}$ (1) [3]
- (d) (i) Average bond enthalpies used (not actual ones) [1]
 (ii) Yes, since answers are close to each other [1]
- (e) Catalyst is in different (physical) state to reactants [1]



Total [16]

4.

- (a) Plotting (2)
Best fit line (1) [3]
- (b) (i) C (1)
Curve steeper (1) [2]
(ii) Concentration of acid is greatest [1]
- (c) $44 \text{ cm}^3 (\pm 1 \text{ cm}^3)$ [1]
- (d) Moles Mg = $0.101/24.3 = 0.00416$ (1)
Moles HCl = $2 \times 0.02 = 0.04$ (1) [2]
- (e) (i) Mg is not the limiting factor /
Mg now in excess / HCl not in excess [1]
(ii) Moles acid = $0.5 \times 0.04 = 0.02$ (1)
Volume $\text{H}_2 = 0.01 \times 24 = 0.24 \text{ dm}^3$
- correct unit needed (1) [2]
- (f) Lower the temperature of the acid (1)
Reactants collide with less energy (1)
Fewer molecules that have the required activation energy (1)[3]
or Use pieces of magnesium (1) less surface area (1) less chance
of successful collisions (1)
QWC Selection of a form and style of writing appropriate to purpose
and to complexity of subject matter. [1]

Total [16]

5.

- (a) to increase rate of reaction /to increase surface area [1]
- (b) $\text{MgCO}_3 + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$ (ignore state symbols) [1]
- (c) rate starts fast and gradually slows (1)
because concentration becomes less so fewer collisions (per unit time) /
less frequent collisions /lower probability of collisions (1)
at time = 17/18 min rate = 0 (1) [3]
- (d) all the solid would all have disappeared /if more carbonate is added further
effervescence is seen [1]
- (e) (i) volume $\text{CO}_2 = 200 \text{ cm}^3$ (1)
moles $\text{CO}_2 = 200 / 24000 = 0.008333 = \text{moles MgCO}_3$ (1)
[minimum 2 sf] [2]
- (ii) mass $\text{MgCO}_3 = 0.008333 \times 84.3 = 0.702 \text{ g}$ (1)
% $\text{MgCO}_3 = \frac{0.702}{0.889} \times 100 = 79.0\% / 79\%$ [2]
- (e) carbon dioxide is soluble in water / reacts with water (1)
volume collected less therefore % / moles of MgCO_3 less (1) [2]
- (f) use of 40.3 and 84.3 (1)
atom economy = $40.3 / 84.3 \times 100 = 47.8\%$ (1) [2]

Total [14]

6.

- (a) Moles NaCl = $\frac{900}{58.5} = 15.38$ (1)
- Moles Na₂CO₃ = 7.69 (1)
- Mass Na₂CO₃ = 7.69 × 106 = 815(.4) g (1) [3]
- (b) (i) 2.52 g [1]
- (ii) Moles Na₂CO₃ = 0.02 (1)
- Moles H₂O = 0.14 (1) x = 7 (1) [2]
- (c) (i) Moles = 0.5 × 0.018 = 0.009 [1]
- (ii) 0.0045 [1]
- (iii) 0.0045 × 106 = 0.477 [1]
- (iv) % = 0.477/0.55 = 86.7 % [1]

Total [10]

7.

(a) percentage Be by mass = 5.03% (1)

division of percentage by A_r for Be and at least one other element as shown below (1)

$$\text{Al} \quad 10.04 \div 27 = 0.3719 \rightarrow 1.00$$

$$\text{Be} \quad 5.03 \div 9.01 = 0.5583 \rightarrow 1.50$$

$$\text{O} \quad 53.58 \div 16 = 3.3488 \rightarrow 9.00$$

$$\text{Si} \quad 31.35 \div 28.1 = 1.1566 \rightarrow 3.10$$

molecular formula = $\text{Al}_2\text{Be}_3\text{O}_{18}\text{Si}_6$ or $x=3$ (1) [3]

(b) (i) Hess' Law states that where a reaction can occur by more than one route the total enthalpy change for each route will be the same [1]

$$(ii) \quad \Delta H = -393.5 - (-395.4) (1) \quad = +1.9 \text{ kJ mol}^{-1} (1) \quad [2]$$

(iii) Kyran is incorrect as diamond is not the **standard state** of carbon [1]

(iv) I mass of diamond = 7.30 g [1]

II mass of graphite = $7.30 \div (93/100) (1) = 7.85 \text{ g} (1) \quad [2]$

Total [10]

8.

- (a) (i) Sample is bombarded by high energy electrons / electron gun used on sample (1)
Electron knocked out (to form ions) (1) [2]
- (ii) So no more than / only 1 electron is knocked out [1]
- (iii) No difference (1)
Same number of electrons (in the outer shell) (1) [2]
- (b) (i) $\frac{(7.25 \times 6) + (92.75 \times 7)}{100}$ (1)
6.928 (1) (accept 6.93) [2]
- (ii) ${}^6\text{Li}^+$ since lower mass / lower m/z / lighter
do not accept 'smaller' [1]
- (c) (i) $M_r(\text{NH}_4)_2\text{SO}_4 = 132.18$ (1)
Moles = 0.0156 (1) [2]
- (ii) Moles LiOH = 0.0312 (1)
Concentration = $\frac{0.0312}{0.0298} = 1.05 \text{ mol dm}^{-3}$ (1) [2]
- (iii) Atom economy = $\frac{34.06}{180.08} \times 100$ (1)
= 18.9% (1) [2]

Total [14]

9.

- (a) (i) I burette / (graduated) pipette [1]
II volumetric / graduated / standard flask [1]
- (ii) 0.0064 [1]
- (iii) 1.20 g / 100 cm³ solution [1]
- (iv) 12.0 g / 100 cm³ solution [1]
- (b) (i) The catalyst is in a different physical state to the reactants. [1]
- (ii) Bonds broken 2 H-H → 872 1 C-O → 360
 1 C-H → 412 1 O-H → 463
 1 C=O → 743
- Total +2850 kJ (1)
- Bonds made 3 C-H → 1236
 1 C-O → 360
 3 O-H → 1389
- Total -2985 kJ (1)
- $\Delta H = 2850 - 2985 = -135 \text{ kJ mol}^{-1}$ (1) [3]
- (c) Relative molecular mass is a relative quantity (based on $1/12$ th of the ¹²C atom as one unit). [1]
- (d) (i) The rate of the forward reaction is equal to the rate of the backward reaction. [1]
- (ii) C₂H₄O [1]
- Total [12]**

10.

- (a) Weighing bottle would not have been washed / difficult to dissolve solid in volumetric flask / final volume would not necessarily be 250 cm^3 [1]
- (b) Pipette [1]
- (c) To show the end point / when to stop adding acid / when it's neutralised [1]
- (d) So that a certain volume of acid can be added quickly before adding drop by drop / to save time before doing accurate titrations / to give a rough idea of the end point [1]
- (e) To obtain a more reliable value [1]
- (f) (i) Moles = $0.730/36.5 = 0.0200$ (1)
- Concentration = $0.02/0.1 = 0.200 \text{ mol dm}^{-3}$ (1) [2]
- (ii) Moles = $0.2 \times 0.0238 = 0.00476$ [1]
- (iii) 0.00476 [1]
- (iv) $0.00476 \times 10 = 0.0476$ [1]
- (v) $M_r = 1.14/0.0476 = 23.95$ [1]
- (vi) Lithium [1]

- mark consequentially throughout (f)

Total [12]

11.

- (a) Filtration [1]
- (b) $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$ [1]
- (c) (i) Carbon O.S. at start = +3; Carbon O. S. at end = +4 [1]
- (ii) $2\text{MnO}_4^- + 16\text{H}^+ + 5\text{C}_2\text{O}_4^{2-} \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 10\text{CO}_2$ [1]
- (d) Colour change of manganate(VII) is used to indicate the change [1]
- (e) Volume of manganate(VII) = 27.92 cm³ (1)
- Moles manganate = $27.92 \times 0.020 / 1000 = 5.584 \times 10^{-4}$ mol (1)
- Moles oxalate = $5.584 \times 10^{-4} \times 5/2 = 1.396 \times 10^{-3}$ mol (1)
- Concentration = $1.396 \times 10^{-3} / 25 \times 10^{-3} = 0.0558$ mol dm⁻³ (1) [4]
- (f) (i) $K_a = \frac{[\text{H}^+][\text{HCOO}^-]}{[\text{HCOOH}]}$ [1]
- (ii) $[\text{H}^+]^2 = K_a \times [\text{HCOOH}] = 1.8 \times 10^{-4} \times 0.2 = 0.36 \times 10^{-4}$ (1)
- $[\text{H}^+] = 6.0 \times 10^{-3}$ mol dm⁻³ (1)
- pH = $-\log [\text{H}^+] = 2.22$ (1) [3]
- (iii) A buffer keeps the pH almost constant when **small amounts** of acid or base are added (1)
- $\text{HCOOH} \rightleftharpoons \text{HCOO}^- + \text{H}^+$ (1)
- Adding acid shifts the equilibrium to the left which removes H⁺ /
Adding base removes H⁺ shifts equilibrium to right which replaces H⁺ (1)
OR answer in terms of H⁺ reacting with methanoate from sodium methanoate when acid added (1) and methanoic acid replacing H⁺ when base removes H⁺ (1)
- MAX 3 [3]
- QWC Selection of a form and style of writing appropriate to purpose and to complexity of subject matter* [1]
- (g) (i) Orange to green [1]
- (ii) CrO₄²⁻ (1) Yellow (1) [2]

Total [20]