

MARK SCHEME for the May/June 2011 question paper
for the guidance of teachers

9701 CHEMISTRY

9701/21

Paper 2 (AS Structured Questions), maximum raw mark 60

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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1 (a) alkanes/paraffins
not hydrocarbon (1) [1]

(b) $2 \text{C}_{14}\text{H}_{30} + 43 \text{O}_2 \rightarrow 28 \text{CO}_2 + 30 \text{H}_2\text{O}$ or

$\text{C}_{14}\text{H}_{30} + \frac{43}{2} \text{O}_2 \rightarrow 14 \text{CO}_2 + 15 \text{H}_2\text{O}$ (1) [1]

(c) (i) mass of $\text{C}_{14}\text{H}_{30}$ burnt

$\frac{8195 \times 10.8}{1000} = 88.506 = 88.5 \text{ t}$ (1)

(ii) mass of CO_2 produced

M_r of $\text{C}_{14}\text{H}_{30} = (14 \times 12 + 30 \times 1) = 198$ (1)

$2 \times 198 \text{ t of } \text{C}_{14}\text{H}_{30} \rightarrow 28 \times 44 \text{ t of } \text{CO}_2$

$88.5 \text{ t of } \text{C}_{14}\text{H}_{30} \rightarrow \frac{28 \times 44 \times 88.5}{2 \times 198}$ (1)

$= 275.3 \text{ t of } \text{CO}_2$ (1)

allow 275.4 t if candidate has used 88.506
allow ecf on wrong value for M_r of $\text{C}_{14}\text{H}_{30}$ [4]

(d) $n = \frac{PV}{RT} = \frac{6 \times 10^5 \times 710 \times 10^{-6}}{8.31 \times 293}$ (1)

$= 0.175$ (1) [2]

(e) $P = \frac{nRT}{V} = \frac{0.175 \times 8.31 \times 278}{710 \times 10^{-6}}$ (1)

$= 569410.5634 \text{ Pa} = 5.7 \times 10^5$ (1)

allow ecf on (d) [2]

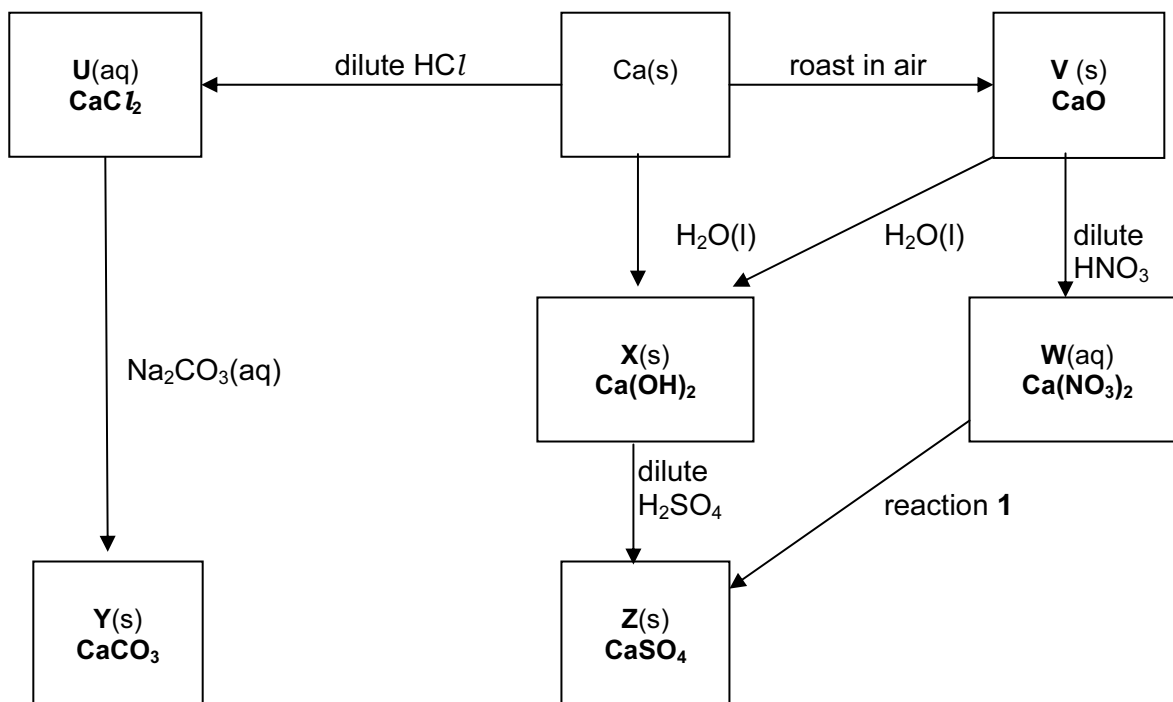
[Total: 10]

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- 2 (a) (i) break large hydrocarbons into smaller hydrocarbons **or**
break down large hydrocarbons (1)
- smaller hydrocarbons are more useful **or**
smaller hydrocarbons are more in demand (1)
- (ii) using high temperatures/thermal cracking **or**
using catalysts/catalytic cracking (1)
- (iii) $C_{14}H_{30} \rightarrow C_7H_{16} + C_7H_{14}$ **or**
 $C_{14}H_{30} \rightarrow C_7H_{16} + C_2H_4 + C_5H_{10}$ **or**
 $C_{14}H_{30} \rightarrow C_7H_{16} + C_3H_6 + C_4H_8$ **or**
 $C_{14}H_{30} \rightarrow C_7H_{16} + 2C_2H_4 + C_3H_6$ (1)
- do not allow any equation with H_2 [4]
- (b) ethanol has hydrogen bonding, ethanethiol does not (1) [1]
- (c) (i) $C_2H_5SH + \frac{9}{2}O_2 \rightarrow 2CO_2 + SO_2 + 3H_2O$ **or**
 $2C_2H_5SH + 9O_2 \rightarrow 4CO_2 + 2SO_2 + 6H_2O$
correct products (1)
correct equation which is balanced (1)
- (ii) **for CO_2**
enhanced greenhouse effect (1)
global warming (1)
- for SO_2**
formation of acid rain (1)
damage to stonework of buildings/
dissolving of aluminium ions into rivers/
damage to watercourses or forests/
aquatic life destroyed/
corrosion of metals (1) [6]
- (d) help detect leaks of gas (1) [1]
- (e) temperature of $450^\circ C$ (1)
pressure of 1 – 2 atm (1)
 V_2O_5 /vanadium(V) oxide/vanadium pentoxide catalyst (1) [3]

[Total: 15]

3



- (a)
- | | | | |
|---|-----------------------------------|-----|-----|
| U | CaCl ₂ | (1) | |
| V | CaO | (1) | |
| W | Ca(NO ₃) ₂ | (1) | |
| X | Ca(OH) ₂ | (1) | |
| Y | CaCO ₃ | (1) | [5] |
- (b) heat strongly in a test-tube or a boiling tube
do not allow 'heat gently' or 'reflux'
- (1) [1]
- (c) (i) Ca to U
Ca + 2HCl → CaCl₂ + H₂
- (1)
- V to W
CaO + 2HNO₃ → Ca(NO₃)₂ + H₂O
- (1)
- U to Y
CaCl₂ + Na₂CO₃ → CaCO₃ + 2NaCl
- (1)
- (ii) 2Ca(NO₃)₂ → 2CaO + 4NO₂ + O₂
- (1) [4]
- (d) Na₂SO₄(aq)/K₂SO₄(aq) or formula of any soluble sulfate
- (1) [1]

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(e) (i) Ca to X
 colourless gas formed/fizzing/effervescence/bubbles **or**
 Ca dissolves **or**
 white precipitate/suspension formed (1)

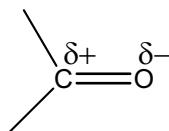
(ii) strongly exothermic/vigorous reaction **or**
 steam formed/steamy fumes **or**
 surface crumbles (1)
 do not allow white ppt. [2]

[Total: 13]

4 (a) (i) nucleophilic addition (1)
both words are necessary

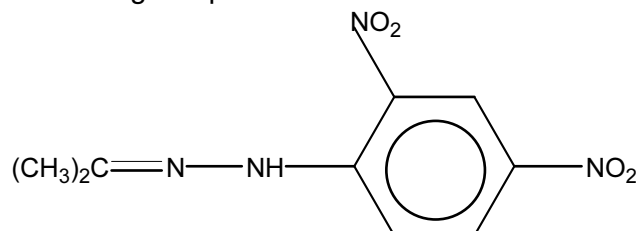
(ii) NaCN and H₂SO₄ **or**
 HCN plus CN⁻ (1)
 do not allow HCN on its own

(iii) correct δ⁺ **and** δ⁻, i.e.



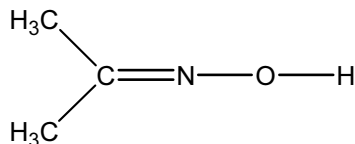
(1) [3]

(b) (i) correct organic product



C=N bond must be clearly shown (1)
 H₂O formed/ equation balanced (1) [2]

(ii)



(1) [1]

[Total: 6]

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5 (a) $\text{CaC}_2 + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{C}_2\text{H}_2$ (1) [1]

(b) (i) step 1 electrophilic addition (1)
step 2 elimination **or** dehydrohalogenation (1)

(ii) reagent NaOH/KOH/OH^- (1)
conditions in alcohol/ethanol (1)
only allow conditions mark if reagent is correct [5]

(c) (i) **Q** is CH_3CHO (as minimum) (1)
R is $\text{CH}_3\text{CO}_2\text{H}$ (as minimum) (1)

(ii) step 3 is addition (1)
step 4 is oxidation/redox (1) [4]

(d) (i) **combustion**
 $\text{C}_2\text{H}_2(\text{g}) + \frac{5}{2}\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ **or**
equation must be for the combustion of one mole of C_2H_2
 H_2O must be shown as liquid (1)
correct state symbols in this equation (1)

formation
 $2\text{C}(\text{s}) + \text{H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_2(\text{g})$
no mark for state symbols here (1)

(ii) let **Z** be ΔH_f° of C_2H_2

$\text{C}_2\text{H}_2 + \frac{5}{2}\text{O}_2 \rightarrow 2\text{CO}_2 + \text{H}_2\text{O}$
 ΔH_f° **Z** 0 2(-394) -286
 $\Delta H_c^\circ = -1300 = 2(-394) + (-286) - \text{Z}$ (1)

whence $\text{Z} = 2(-394) + (-286) - (-1300)$
 $= +226 \text{ kJ mol}^{-1}$
value (1)
sign (1)
allow ecf on wrong equation [6]

[Total: 16]

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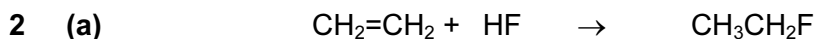


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- 1 (a) $K_c = \frac{[\text{CH}_3\text{CH}_2\text{R}][\text{H}_2\text{O}]}{[\text{CH}_3\text{CH}_2\text{H}][\text{ROH}]}$ (1)
no units (1) [2]
- (b) (i) $n(\text{NaOH}) = \frac{22.5 \times 2.00}{1000} = 0.045$ (1)
- (ii) $n(\text{NaOH}) = n(\text{HCl}) = 0.005$ (1)
- (iii) $\text{CH}_3\text{CO}_2\text{H} + \text{NaOH} \rightarrow \text{CH}_3\text{CO}_2\text{Na} + \text{H}_2\text{O}$ (1)
- (iv) $n(\text{NaOH}) = 0.045 - 0.005 = 0.04$ (1)
allow ecf on (i) and/or (ii) [4]
- (c) (i) $n(\text{NaOH})$ and $n(\text{CH}_3\text{CO}_2\text{H}) = 0.04$ (1)
 $n(\text{CH}_3\text{CO}_2\text{R})$ and $n(\text{H}_2\text{O}) = 0.06$ (1)
- (ii) $K_c = \frac{0.06 \times 0.06}{0.04 \times 0.04} = 2.25$ (1)
allow ecf on wrong values in (b)(i)
allow ecf on wrong expression in (a) (1) [3]
- (d) E_a for reaction with ester is high or
 E_a for reaction with acid is low
or
reaction with ester is slow or
reaction with acid is fast (1) [1]
- (e) equilibrium moves to RHS/more ester would be formed (1)
to maintain value of K_c or
to restore system to equilibrium (1) [2]

[Total: 12]

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bonds	4 C-H	1640	bonds	5 C-H	2050
broken	1 C=C	610	made	1 C-C	350
/kJ mol ⁻¹	1 H-F	<u>562</u>	/kJ mol ⁻¹	1 C-F	<u>E</u>
		2812			(2400 + E)

breaking reactant bonds requires

$$4 \times 410 + 610 + 562 = 2812 \text{ kJ mol}^{-1} \quad (1)$$

making product bonds gives

$$5 \times 410 + 350 + E = (2400 + E) \text{ kJ mol}^{-1} \quad (1)$$

$$\Delta H^\circ_{\text{reaction}} = - (2400 + E) + 2812 = -73 \text{ kJ mol}^{-1} \quad (1)$$

$$(2400 + E) = 2812 + 73 = 2885 \text{ kJ mol}^{-1}$$

$$E = 2885 - 2400 = 485 \text{ kJ mol}^{-1} \quad (1)$$

allow ecf on wrong bond energy values and/or incorrect arithmetic [4]

- (b) any **two** from
 non-toxic
 unreactive
 volatile
 non-flammable
 easily liquefied

(1 + 1) [2]

- (c) in CCl_2F_2

C-Cl bond energy is 340 kJ mol⁻¹ and is weaker than C-F or C-H bonds (1)

C-Cl bond is broken by uv light **or**

Cl free radicals are formed (1) [2]

- (d) (i) the trapping of reflected heat from the Earth in the lower atmosphere
 producing global warming

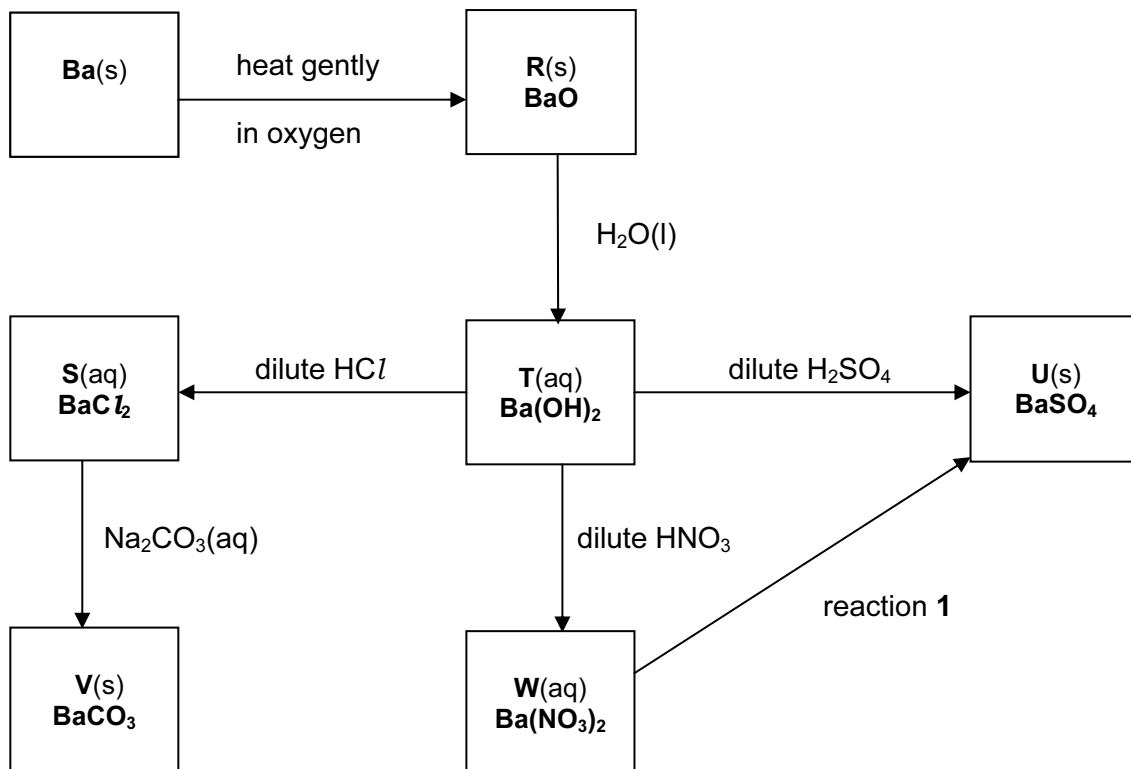
(ii) CO₂/carbon dioxide (1) [3]

- (e) octahedral

(1) [1]

[Total: 12]

3



- (a) R BaO (1)
 S BaCl₂ (1)
 T Ba(OH)₂ (1)
 U BaSO₄ (1)
 V BaCO₃ (1)
 W Ba(NO₃)₂ (1) [6]
- (b) (i) T to W
 $\text{Ba(OH)}_2 + 2\text{HNO}_3 \rightarrow \text{Ba(NO}_3)_2 + 2\text{H}_2\text{O}$ (1)
- heat on V
 $\text{BaCO}_3 \rightarrow \text{BaO} + \text{CO}_2$ (1)
- (ii) T to V
 CO_2 (1)
 $\text{Ba(OH)}_2 + \text{CO}_2 \rightarrow \text{BaCO}_3 + \text{H}_2\text{O}$ (1) [4]
- (c) Na₂SO₄(aq)/K₂SO₄(aq) or any soluble sulfate (1) [1]

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(d) (i) $\text{Ba}:\text{O} = \frac{81.1}{137} : \frac{18.9}{16}$ (1)

$$= 0.59 : 1.18$$

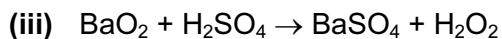
$$= 1 : 2$$

gives BaO_2

(1)



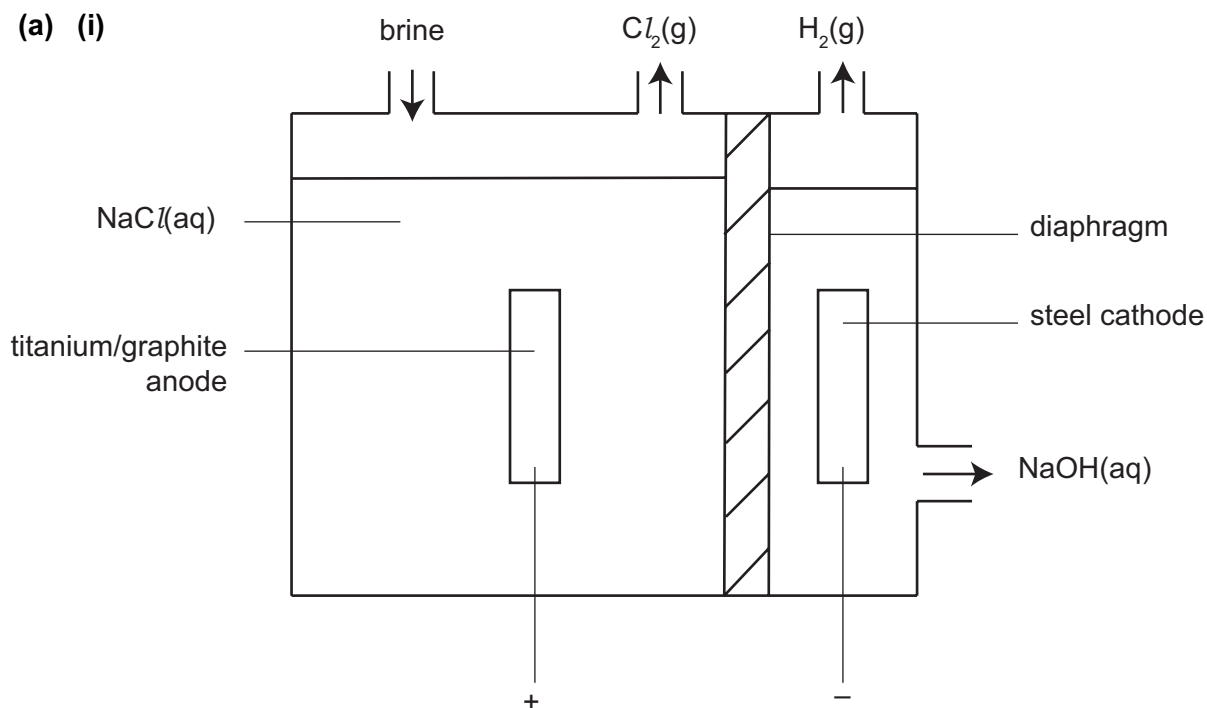
(1)



(1) [4]

[Total: 15]

4 (a) (i)



titanium/graphite anode identified correctly

(1)

steel cathode identified correctly

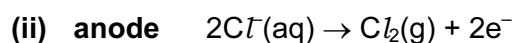
(1)

diaphragm identified correctly

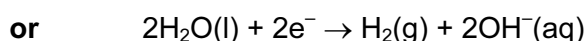
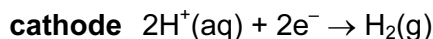
(1)

all three outlets correctly shown

(1) [4]



(1)



(1) [2]

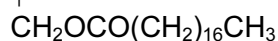
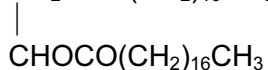
(iii) sodium hydroxide

(1) [1]

[Total: 7]

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5 (a) $\text{CH}_2\text{OCO}(\text{CH}_2)_{16}\text{CH}_3$



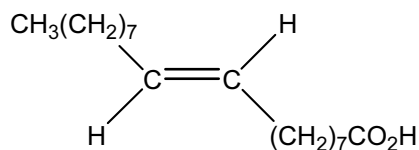
all three alcohol groups must be esterified

(1) [1]

(b) dilute HCl **or** dilute H_2SO_4 **or** dilute mineral acid
or $\text{NaOH}(\text{aq})$ **followed by** dilute acid

(1) [1]

(c)



(1) [1]

(d) (i) fatty acid that contains more than one $\text{C}=\text{C}$ bond

(1)

(ii) hydrogen
nickel/Raney nickel/platinum/palladium

(1)

(1) [3]

(e) (i) $\text{CH}_3(\text{CH}_2)_7\text{CHO}$
 $\text{OHC}(\text{CH}_2)_7\text{CX}$

(1)

(1)

(ii) 2,4-dinitrophenylhydrazine
yellow/orange/red precipitate

(1)

(1)

(iii) Tollens' reagent **or** Fehling's/Benedict's solution
silver mirror/ **or** brick red ppt.
grey precipitate

(1)

(1) [6]

(f) (i) two

(1)

(ii) ester

(1) [2]

[Total: 14]

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1 Throughout this question, deduct **one mark only** for sig. fig. error.

(a) (i) the volume of solution **A** present in one 'typical ant' is
 $7.5 \times 10^{-6} \times 1000 = 7.5 \times 10^{-3} \text{ cm}^3$ (1)

(ii) the volume of pure methanoic acid in one 'typical ant' is
 $7.5 \times 10^{-3} \times \frac{50}{100} = 3.75 \times 10^{-3}$ gives $3.8 \times 10^{-3} \text{ cm}^3$

allow ecf on (i) (1)

(iii) no. of ants = $\frac{1000}{3.8 \times 10^{-3}} = 263157.8947$ gives 2.6×10^5

use of 3.75×10^{-3} gives $266666.6667 = 2.7 \times 10^5$ (1) [3]

(b) (i) the volume of solution **A**, in one ant bite is
 $\frac{80}{100} \times 7.5 \times 10^{-3} = 6.0 \times 10^{-3} \text{ cm}^3$

allow ecf on (a)(i) (1)

the volume of pure methanoic acid in one bite is
 $\frac{50}{100} \times 6.0 \times 10^{-3} = 3.0 \times 10^{-3} \text{ cm}^3$

allow ecf on first part of (b)(i) (1)

(ii) the mass of methanoic acid in one bite is
 $3.0 \times 10^{-3} \times 1.2 = 3.6 \times 10^{-3} \text{ g}$

allow ecf on (b)(i) (1) [3]

(c) (i) $\text{HCO}_2\text{H} + \text{NaHCO}_3 \rightarrow \text{HCO}_2\text{Na} + \text{H}_2\text{O} + \text{CO}_2$ (1)

(ii) $46 \text{ g HCO}_2\text{H} \equiv 84 \text{ g NaHCO}_3$ (1)

$5.4 \times 10^{-3} \text{ g HCO}_2\text{H} \equiv \frac{84 \times 5.4 \times 10^{-3}}{46} \text{ g NaHCO}_3$
 $= 9.860869565 \times 10^{-3}$
 $= 9.9 \times 10^{-3} \text{ g NaHCO}_3$ (1) [3]

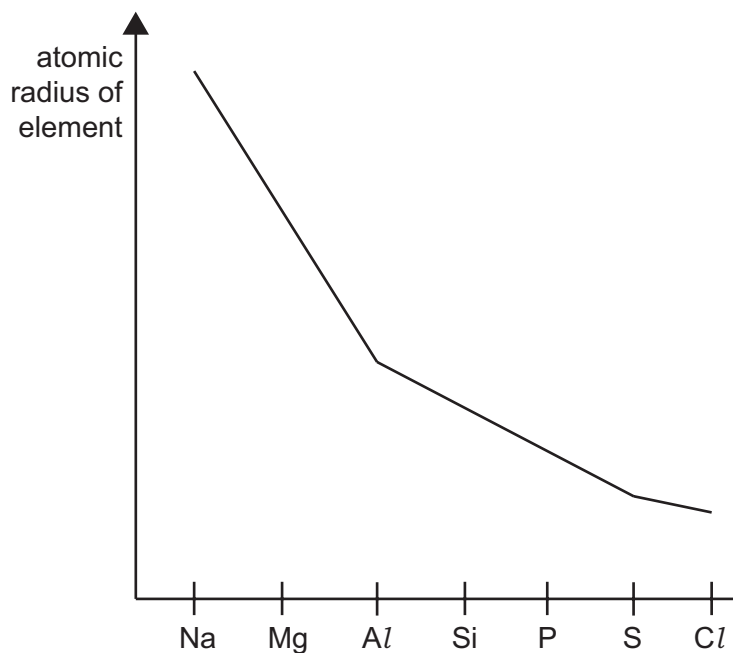
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- 2 (a) there are no inter-molecular forces present between ideal gas molecules
ideal gas molecules have no volume
collisions between ideal gas molecules are perfectly elastic
ideal gas molecules behave as rigid spheres (any 2) [2]
- (b) high temperature (1)
low pressure (1) [2]
- (c) **most ideal** neon..... nitrogen..... ammonia..... **least ideal** (1)
nitrogen has stronger van der Waals' forces than argon (1)
ammonia has hydrogen bonding as well as van der Waals' forces (1) [3]
- (d) with increasing temperature,
average kinetic energy of molecules increases (1)
intermolecular forces are more easily broken (1) [2]
- (e) 18 (1) [1]
- (f) (i) both have very similar/same van der Waals' forces (1)
(ii) CH₃F has permanent dipole (1) [2]

[Total: 12]

3 (a)



general shape of curve

(1)

for Na → Ar

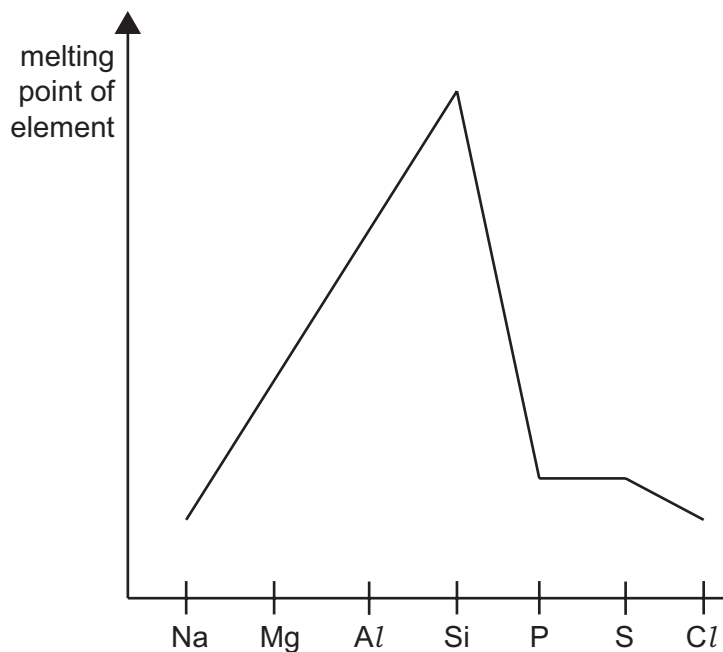
nuclear charge increases

(1)

electrons are added to same shell

(1) [3]

(b)



general shape of curve

(1)

Na, Mg and Al have metallic bonding

(1)

Si is giant molecular

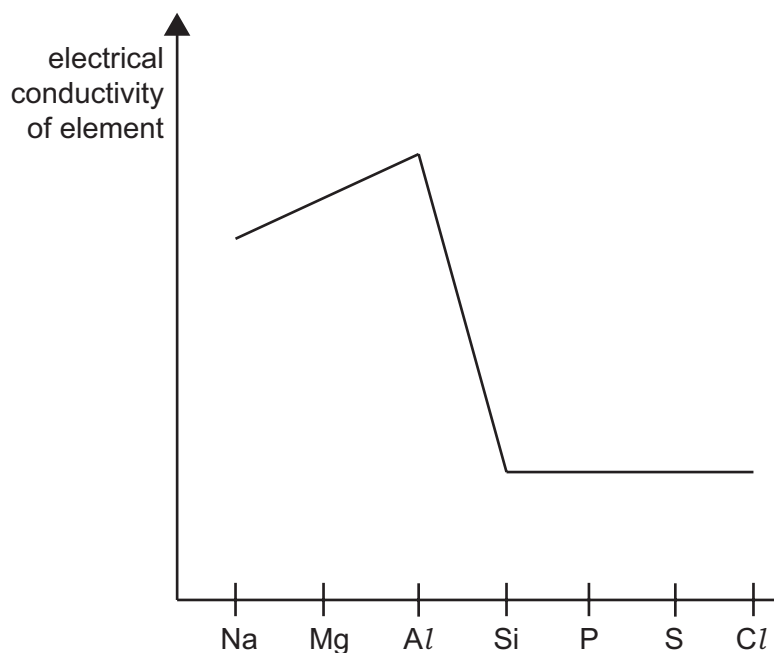
(1)

P, S, and Cl are simple molecular

(1) [4]

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(c)



general shape of curve

(1)

Na, Mg and Al have increasing no. of outer shell electrons

(1)

Si is a semi-conductor

(1)

P, S and Cl are covalent/simple molecular

(1) [4]

- (d) (i) Na_2O ionic (1)
 SiO_2 covalent (1)
 P_4O_6 van der Waals' forces/induced dipoles (1)

(ii) Al_2O_3 or SiO_2

(1) [4]

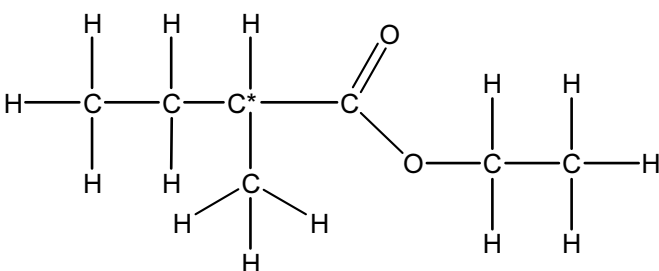
[Total: 15]

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- 4 (a) $C_9H_{16}O_2$ (1) [1]
- (b) (i) aldehyde **not** carbonyl (1)
secondary (1)
alcohol (1)
- (ii) Br_2 /bromine **allow** $KMnO_4/H^+$ (1)
decolourised decolourised (1) [5]
- (c) (i) $CH_3(CH_2)_4COCO_2H$ (1)
 HO_2CCO_2H **or** CO_2 (1)
- (ii) $CH_3(CH_2)_4CH(Cl)CH=CHCHO$ (1)
- (iii) $CH_3(CH_2)_4CH(OH)CH=CHCH_2OH$ (1) [4]

[Total: 10]

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- 5 (a) (i) $C_7H_{14}O_2$ (1)
- (ii) one (1) [2]
- (b) (i) $Cr_2O_7^{2-}/H^+$ (1)
from orange (1)
to green (1)
- (ii) 2-ethyl-3-methylbutanal/ $(CH_3)_2CHCH(C_2H_5)CHO$ /the corresponding aldehyde (1)
partial oxidation of alcohol will produce aldehyde (1)
- (iii) reflux **because** (1)
the alcohol must be fully oxidised [6]
- (c) none (1)
alcohol is tertiary (1)
cannot be oxidised (1) [3]
- (d)
- 
- correct structure (1)
fully displayed $-CO_2C_2H_5$ group (allow ecf on wrong esters) (1)
correct chiral C atom (allow ecf on wrong esters) (1) [3]

[Total: 14]