Atomic Structure

Mark Scheme 4

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Atomic Structure
Sub-Topic	
Paper Type	Theory
Booklet	Mark Scheme 4

Time Allowed: **83 minutes**

Score: **/69**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** **(i)** 162 ($^{81}Br^{-}$ $^{81}Br^{+}$) for molecular species [1]
160 ($^{81}Br^{-}$ $^{79}Br^{+}$) for atomic species [1]
158 ($^{79}Br^{-}$ $^{79}Br^{+}$) *ignore missing charges* for 5 masses [1]
81 ($^{81}Br^{+}$)
79 ($^{79}Br^{+}$)

(ii) 158:160:162 =1:2:1 [1]
79:81 =1:1 [1]

(b) *either* $BrCH_2CHBr\text{-}CHO$ *or* $CH_2{=}CH\text{-}CH_2OH$ (double bond needed) [1]

(ii) reaction I: Br_2(aq or in CCl_4 etc.), light negates – *solvent not needed* [1]
reaction II: $NaBH_4$ *or* H_2/Ni etc. (but not if **A** is $CH_2{=}CH\text{-}CH_2OH$)
allow $LiAlH_4$ or Na/ethanol [1]
(*reactions can be reversed*)

(c) $C_3H_6OBr_2$ = 216, 218 and 220 (any one) [1]

(ii)

31	is	CH_2OH^+/CH_3O^+	
106	is	$C_2H_3{}^{79}Br^+$	
108	is	$C_2H_3{}^{81}Br^+$	
185	is	$C_2H_3{}^{79}Br_2{}^+$	*ignore missing charges*
187	is	$C_2H_3{}^{79}Br^{81}Br^+$	6 correct [4]
189	is	$C_2H_3{}^{81}Br_2{}^+$	5 correct [3] etc

if no mass numbers given – [1] only [4]

[Total: 13 max 12]

2 **(a) (i)** $K_a = [H^+][RCO_2^-]/[RCO_2H]$ [1]

(ii) $pK_a = -\log_{10}K_a$ *or* $-\log K_a$ *or* $\log [H^+]^2/[RCO_2H]$ NOT *l*n; [
[2]

(b) acid strength increases from no. 1 to no. 3 *or* down the table *or* as C*l*s increase [1]
due to the electron-withdrawing effect/electronegativity of chlorine (atoms) [1]
stabilising the anion *or* weakening the O-H bond NOT H^+ more available [1]

(ii) chlorine atom is further away (from O-H) in no. 4, so has less influence [1]

(iii) *either:* $pH = ½ (pK_a - \log_{10}[acid])$ *or* $K_a = 10^{-pKa} = 1.259 \times 10^{-3}$
$= ½ (4.9 + 2)$ $[H^+] = \sqrt{(K_a . c)} = 3.55 \times 10^{-4}$ [1]
$= 3.4$ (allow 3.5) pH = 3.4 ecf [1]
([1] for correct expression & values; [1] for correct working)
[6]

(c) (i) catalyst [1]

(ii) $CH_3CH_2CO_2H + Cl_2 \longrightarrow CH_2CHClCO_2H + HCl$ [1]

(iii) nucleophilic substitution NOT addition/elimination [1]

(iv) $M_r (CH_3CH_2CO_2H) = 74$ $M_r(CH_2CH(NH_2)CO_2H) = 89$ [1]
$\therefore$ 10.0 g should give 10 x 89/74 = 12.03 g
$\therefore$ percentage yield = 100 x 9.5/12.03 = **79%** ecf [1]
([2] for correct answer)
[5]

(d) $^+NH_3\text{-}CH(CH_3)\text{-}CO_2^-$ correct atoms [1]
Allow charges on H of H_3N, and –COO but not –C-O-O correct charges [1]
[2]

[Total: 15]

3 **(a** same proton no./atomic no./no. of protons **(1)**
different mass no./nucleon no./no. of neutrons **(1)** **[2]**

(b)

	number of		
isotope	p	neutrons	electrons
^{56}Fe	**26**		
^{59}Co	**27**		
	(1)	**(1)**	**(1)**

give one mark for each correct column
allow **(1)** if no column is correct but one row is correct **[3]**

(c) weighted mean/average mass
of an atom (not element) **(1)**
compared with ^{12}C **(1)**
one atom of ^{12}C has a mass of exactly 12 **(1)**
[relative to $^{1}/_{12}^{th}$ the mass of a ^{12}C atom would get 2]

or

mass of 1 mol of atoms **(1)**
compared with ^{12}C **(1)**
1 mol of ^{12}C has a mass of 12 g **(1)**

(ii) $A_r = \frac{54 \times 5.84 + 56 \times 91.68 + 57 \times 2.17}{100}$ **(1)**

$= \frac{5573.13}{100} = 55.7$ to 3 sf **(1)**

allow 55.9 if A_r is calculated using 99.69 instead of 100 **[5]**

[Total: 10]

4 **(a)** Atoms which have the same number of protons (or same element) but different numbers of neutrons (1) **[1]**

(b) **(i)** ^{35}Cl (1)

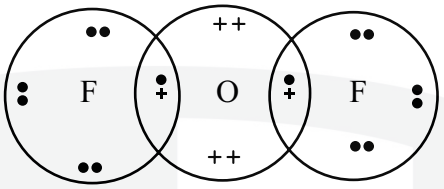
(ii) $H^{37}Cl$ (1) **[2]**

(c) H Cl line at 36 has rel. abundance of 90
38 30

These show ^{35}Cl and ^{37}Cl in ratio 3:1 (1)
[or use of 35 and 37] **[2]**

(d) Mean of the two isotopes $\frac{3 \times 35 + 1 \times 37}{4} = 35.5$ (1) **[1]**

[Total: 6]

Question	point	Marks
5 **(a)**	oxygen: $(1s^2)\ 2s^2 2p^4$ fluorine: $(1s^2)\ 2s^2 2p^5$	**1**
(b) (i)	F_2O / OF_2	**1**
(ii)		**1**
(iii)	bent ***or*** non-linear	**1**
(c) (i)	$E^{\ominus}$ values: F_2 / F^- = 2.87 V **and** Cl_2 / Cl^- = 1.36 V fluorine (has the more positive $E^{\ominus}$ so) is more oxidising	**1** **1**
(ii)	redox	**1**
(iii)	$ClF + 2KBr \longrightarrow KCl + KF + Br_2$	**1**
		[Total: 8]

Question	Scheme	Mark	T
6 **(a)**	The amount of energy required / energy change / enthalpy change when one electron is removed from each atom / (cat)ion in one mol of gaseous atoms / (cat)ions **OR** energy change when 1 mole of electrons is removed from one mole of gaseous atoms / ions $X(g) \rightarrow X^{+}(g) + e^{-}$ gains 2 marks	1 1 1	3
(b) (i)	Group V / 5 / 15 Big difference between fifth and sixth ionisation energies	1 1	2
(ii)	$1s^2\ 2s^2\ 2p^3$ ecf from **(b)(i)** if period 2	1	
(c) (i)	(Weighted) mean / average mass of an atom(s) (of an element) Relative to $1/12^{th}$ of (the mass of an atom of) carbon-12 **OR** relative to carbon-12 which is (exactly) 12 (units) allow as an expression	1 1	2
(ii)	$\frac{\textbf{Z}}{\frac{31.13}{A_r}} \quad \frac{Cl}{\frac{68.87}{35.5}} = 1:2$ So $\frac{68.87/35.5}{31.13/A_r} = 2$ $A_r = \frac{2 \times 31.13 \times 35.5}{68.87} = 32.0923 = 32.1$ to 3s.f. Allow alternative correct methods	1 1	2

Question	Scheme	Mark	T
(d) (i)	$NaCl$ (+ aq) → $Na^+ + Cl^-$ $NaCl + H_2O$ → $Na^+ + Cl^- + H_2O$ $SiCl_4 + 2H_2O$ → $SiO_2 + 4HCl$ $SiCl_4 + 4H_2O$ → $Si(OH)_4 + 4HCl$ $SiCl_4 + 4H_2O$ → $SiO_2.2H_2O + 4HCl$ Allow correct equation with other molar amounts of water	1 1	 2
(ii)	$NaCl$ is ionic **AND** giant / lattice $NaCl$ dissolves / does not react $SiCl_4$ is <u>covalent</u> **AND** molecular / simple $SiCl_4$ is hydrolysed / reacts	1 1 1 1	 4
(e)	shape of SF_6 = Octahedral bond angle = 90°	1 1	 2
			18