Atoms, Molecules & Stoichiometry

Mark Scheme 3

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Atoms, Molecules & Stoichiometry
Sub-Topic	
Paper Type	Theory
Booklet	Mark Scheme 3

Time Allowed: **77 minutes**

Score: **/64**

Percentage: **/100**

Grade Boundaries:

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

1 **(a)** **(i)** mass of C = $\frac{12 \times 0.352}{44}$ = 0.096g (1)

n(C) = $\frac{0.096}{12}$ = 0.008 (1)

(ii) mass of H = $\frac{2 \times 0.144}{18}$ = 0.016g (1)

n(H) = $\frac{0.016}{1}$ = 0.016 (1)

(iii) mass of oxygen = 0.240 – (0.096 + 0.016) = 0.128g (1)

n(O) = $\frac{0.128}{16}$ = 0.008 (1)

allow ecf at any stage [6]

(b) C : H : O = 0.008: 0.016 : 0.008 = 1:2:1

allow C : H : O = $\frac{0.096}{12}$: $\frac{0.016}{1}$: $\frac{0.128}{16}$ = 1:2:1

gives C H_2O (1 [1]

(c) **(i)** $M_r = \frac{mRT}{pV} = \frac{0.148 \times 8.31 \times 333}{1.01 \times 10^5 \times 67.7 \times 10^{-6}}$ (1)

= 59.89

allow 59.9 or 60 (1)

(ii) $C_2H_4O_2$ (1) [3]

(d) CH_3CO_2H (1)

HCO_2CH_3 **(1)**

(e) the only products of the reaction are the two oxides H_2O and CO_2 and copper (1) [1]

[Total: 13]

2 **(a)** Cr^{3+}: 1 $^2 2s^2 2p^6$ **$3s^2$ $3p^6$ $3d^3$** [1]
Mn^{2+}: 1 $^2 2s^2 2p^6$ **$3s^2$ $3p^6$ $3d^5$** [1]
[2]

(b) **(i)** Any two from
- H^+ is on the oxidant/L.H. side of each of the ½-equations, *or* H^+ is a reactant
- (increasing $[H^+]$) will make $E^\ominus$ more positive
- (increasing $[H^+]$) will drive the reaction over to the R.H./reductant side *or* forward direction

[1] +

(ii) $KMnO_4$: Purple/violet to colourless (allow ***very*** pale pink) [1]
$K_2Cr_2O_7$ Orange to green [1]
[4]

(c) **(i)** $MnO_2 + SO_2 \longrightarrow MnSO_4$ (*or* $Mn^{2+} + SO_4^{2-}$) [1

manganese changes/is reduced from +4 to +2 [1]
sulfur changes/is oxidised from +4 to +6 [1]

(ii) **No effect**, because H^+ does not appear in the overall equation *or* its effect on the MnO_2/Mn^{2+} change is cancelled out by its effect on the SO_2/SO_4^{2-} change [1]
[4]

(d) **(i)** $MnO_2 + 4H^+ + Sn^{2+} \longrightarrow Mn^{2+} + 2H_2O + Sn^{4+}$ [1]

(ii) $n(MnO_4^-) = 0.02 \times 18.1/1000 = 3.62 \times 10^{-4}$ mol [1]
$n(Sn^{2+}) = 3.62 \times 10^{-4} \times 5/2 = 9.05 \times 10^{-4}$ mol [1]
$n(Sn^{2+})$ that reacted with $MnO_2 = (20 - 9.05) \times 10^{-4} = 1.095 \times 10^{-3}$ mol [1]
reaction is 1:1, so this is also $n(MnO_2)$
mass of $MnO_2 = 1.095 \times 10^{-3} \times (54.9+16+16) = 0.0952$ g [1]
$\Rightarrow$ **95% – 96%;** 2 or more s.f. [1]
[6]

[Total: 16]

3 **(a** the actual number of atoms of each element present (1)

in one molecule of a compound (1) [2]

(b) $C_xH_y + \left(x + \frac{y}{4}\right)O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O$

xCO_2 (1)

$\frac{y}{2}H_2O$ (1) [2]

(c) **(** oxygen/O_2 (1)

(ii) carbon dioxide/CO_2 (1)

(iii) 10 cm^3 (1)

(iv) 20 cm^3 (1) [4]

(d) $C_xH_y + \left(x + \frac{y}{4}\right)O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O$

10 cm^3 20 cm^3 10 cm^3

1 mol of C_xH_y gives 1 mol of CO_2

whence $x = 1$ (1)

1 mol of C_xH_y reacts with 2 mol of O_2

whence $\left(x + \frac{y}{4}\right) = 2$

and $y = 4$ (1)

molecular formula is CH_4 (1) [3]

[Total: 11]

4 **(a** A*l* $1s^2\ 2s^2 2p^6\ 3s^2 3p^1$ (1)

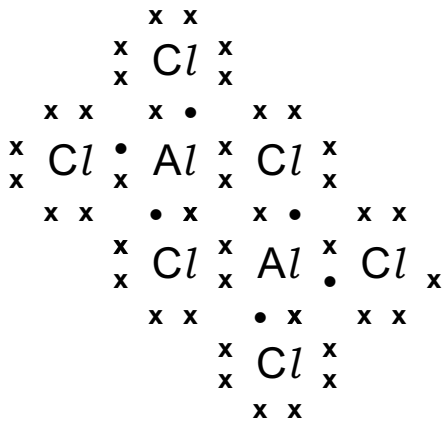
Ti $1s^2\ 2s^2 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^2$ **or**

$1s^2\ 2s^2 2p^6\ 3s^2\ 3p^6\ 4s^2 3d^2$ penalise any error (1) [2]

(b) **(i)** pass chlorine gas (1)
over heated aluminium (1)

(ii) aluminium glows (1)
white/yellow solid formed (1)
chlorine colour disappears/fades (1) (any 2)

(iii)



correct numbers of electrons, i.e.

3 • per A*l* atom **and 7x** per C*l* atom

i.e. 6 • and 42 **x** in total (1)

dative bond C*l* to A*l* clearly shown by $^{x}_{x}$ (1) [6]

(c) chlorine is a strong/powerful oxidising agent (1) [1]

(d) **(i)** $n(Ti) = \frac{0.72}{47.9} = 0.015$ (1)

(ii) $n(Cl) = \frac{(2.85 - 0.72)}{35.5} = 0.06$ (1)

(iii) 0.015 : 0.06 = 1:4
empirical formula of **A** is $TiCl_4$
Allow ecf on answers to **(i)** and/or **(ii)**. (1)

(iv) $Ti + 2Cl_2 \rightarrow TiCl_4$ (1)
Allow ecf on answers to **(iii)**. [4]

(e) covalent/not ionic (1)
simple molecular **or**
mention of weak intermolecular forces **or**
weak van der Waals's forces between molecules (1) [2]

[Total: 14 max]

5 **(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]