2.7 EXTRA QUESTIONS MS

1.

(a) $\underset{\smile}{C + Cl_2}$ (or in eq^n) **(1)**

heat <u>or</u> 500–1000°C **(1)** 2

(b) electrolysis **(1)**

molten <u>or</u> with cryolite **(1)** 2

[4]

2. *Equation(s) for iron* $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$ **(1)**

(3CO) $(3CO_2)$

<u>or</u> Fe_3O_4

Equation(s) for aluminium $Al^{3+} + 3e \rightarrow Al$ **(1)**

$O^{2-} \rightarrow \frac{1}{2} O_2 + 2e$ **(1)** 3

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3. Na <u>or</u> Mg **(1)**

Heat (500–1000°C) **(1)** Ar or inert atmos **(1)**

$TiCl_4 + 4Na\ (2Mg) \rightarrow Ti + 4NaCl\ (2\ MgCl_2)$ **(1)** 4

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4. (a) (i) *Stage 1* $C + O_2 \longrightarrow CO_2$ **(1)**

Stage 2 $CO_2 + C \longrightarrow 2\ CO$ **(1)**

(ii) *Equation for carbon* $Fe_2O_3 + 3C \longrightarrow 2\ Fe + 3CO$ **(1)**

or $2Fe_2O_3 + 3C \longrightarrow 4Fe + 3CO_2$

Equation for carbon monoxide $Fe_2\ O3 + 3CO \longrightarrow 2\ Fe + 3CO_2$ **(1)**

(iii) *Impurity* SiO_2 **(1)**

Equation $CaCO_3 \longrightarrow CaO + CO_2$ **(1)**

$CaO + SiO_2 \longrightarrow CaSiO_3$ **(1)** 7

(b) *Gas* CO_2 **(1)**

Environmental problem Global warming **(1)** 2

(c) *Gas* SO_2 **(1)**

Environmental problem Acid rain **(1)** 2

[11]

5. (a) $TiO_2 + 2C + 2Cl_2 \longrightarrow TiCl_4 + 2CO$

Correct species **(1)**

Correctly balanced **(1)** 2

(b) *Reducing agent* Na or Mg **(1)**

Conditions Heat **(1)**

Inert atmosphere or argon **(1)**

Equation $TiCl_4 + 4Na \longrightarrow Ti + 4NaCl$ **(1)**

or $TiCl_4 + 2Mg \longrightarrow Ti + 2MgCl_2$ 4

(c) Titanium carbide formed **(1)** 1

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6. *Transfer marks between section of this question*

(a) **Aluminum** Electrolysis (*not electricity*) of melt or implied **(1)**

If both Al_2O_3 and cryolite given, allow "at 1000°C" or temperature above m.pt, as "molten" otherwise ignore any given temperature even if wrong.

Cryolite needed **(1)**

Carbon or graphite electrodes **(1)**

Do not allow carbon anode on its own

$Al^{3+} + 3e^{(-)} \rightarrow A1$ (or any multiple) **(1)**

$2O^{2-} \rightarrow O_2 + 4e^{(-)}$ (or any multiple) **(1)** 5

If aqueous solution given allow max 2 (i.e. for carbon electrodes and equation giving O2)

If aqueous only in equations, penalise only the equation for Al extaction

Titanium Oxide converted to chloride using C and CL_2 (Q of L mark) **(1)**

Note;- oxide ores are rutile and ilmenite

or $TiO_2 + 2C + 2Cl_2 \rightarrow TiCl_4 + 2CO$

$TiO_2 + C + 2Cl_2 \rightarrow TiCl_4 + CO_2$ **(1)**

$TiCl_4$ purified by distillation **(1)**

$TiCl_4$ reduced by / reacted with an active metal or Na or Mg **(1)**

Note;- only allow Na and Mg as the active metals (Q of L mark)

either $TiCl_{4\,+}\,4Na \rightarrow Ti + 4NaCl$

or $TiCl_4 + 2Mg \rightarrow Ti\ 2MgCl_2$ **(1)**

Note;;- allow if both given but one incorrect

Reduction carried out under inert atmosphere or Ar **(1)** max 5

Do not allow nitrogen as an inert gas and ignore temperatures even if wrong

(b) **Explanation**

Aluminium Electolysis gives pure A1 or process continuous **(1)**

Carbon reduction gives an impure product or carbide **(1)**

Metal displacement is too expensive/a batch process or batch process gives small amout A1 **(1)**

Titanium (Only) TiC *or name* formed when TiO_2 reacts with C

or TiO_2 cannot be reduced by C **(1)**

Allow TiC from an incorrect equation provided it starts with TiO2 and C

Ti useless *or brittle* when impure or converse **(1)** max 4

(c) **Recycling**

Expensive electrolysis or lots of electricity needed to extract Al (from Al_2O_3) **(1)**

Recycling Al from scrap means only heat needed or requires less energy **(1)**

Pollution by either no need to dispose of Al scrap (e.g. by landfill)

or less extraction of $Al_2O_{3,}$ less holes

or less red mud waste

or A1 or fluoride or cryolite *toxicity*/health risk **(1)**

Do not allow cheaper or less expensive 3

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7. (a) (TiO_2) treated with Cl_2 **(1)**

and C (coke) **(1)**

Note, if other incorrect reagent mentioned lose one mark for each wrong reagent after 2 marks scored up to -2

at high temperature **(1)**

If specific temperature mentioned allow between 500 to 1000°C

$TiCl_4$ formed **(1)**

$TiO_2 + 2C + 2Cl_2 \rightarrow TiCl_4 + 2CO$ **(1)**

Note, equation can also score C, Cl_2 and $TiCl_4$ marks

Or $TiO_2 + C + 2\,Cl_2 \rightarrow TiCl_4 + CO_2$

($TiCl_4$ reacts with) Na or (Mg) **(1)**

under argon **(1)**

$TiCl_4 + 4Na \rightarrow 4NaCl + Ti$ **(1)**

Note this equation also scores the Na mark

Energy for TiO_2 conversion into $TiCl_4$ expensive

Raw materials in reduction of $TiCl_4$ expensive (or Na or Cl_2 expensive) **(1)**

Precautions to keep $TiCl_4$ dry (or prevent hydrolysis) expensive **(1)**

Batch process (expensive) **(1)** max 11

(b) (In blast furnace) add limestone (or $CaCO_3$) **(1)**

$CaCO_3 \rightarrow CaO + CO_2$ **(1)**

$SiO_2 + CaO \rightarrow CaSiO_3$ **(1)**

or mark 2 for combined equation $CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2$

Limestone mark can be scored in an equation

Forms slag **(1)**

4

(c) Iron scrap must be separated from other metals etc **(1)**

Using magnet **(or using magnetic properties) (1)**

It is then melted down (to convert it into steel) **(1)**

And also used in BOS process **(1)**

Use of scrap requires less energy than extraction **(1)**

Because has higher iron content than ore OR scrap does not deplete native ore reserves **(1)**

Scrap removed from countryside **(1) (or any environmental issue e.g. mining but not greenhouse effect)**

Less CO_2 released into atmosphere (hence greenhouse effect) (compared with extraction) **(1)** Max 6

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8. (a) *Reducing agent 1:* C**(1)** (or coke)
Not coal

Equation: $3C + Fe_2O_3 \rightarrow 3CO + 2Fe$ **(1)**
or $+ 2Fe_2O_3 \rightarrow 3CO_2 + 4Fe$
$C + O_2 \rightarrow CO_2$
$C + ½ O_2 \rightarrow CO$
$CO_2 + C \rightarrow 2CO$
penalise Fe_2
(allow Fe_3O_4 *and FeO)*

Reducing agent 2: CO **(1)**

Equation: $3CO + Fe_2O_3 \rightarrow 3CO_2 + 2Fe$ **(1)** 4
(again allow Fe3O4, FeO)

Equation mark depends on correct reducing agent, but allow coal

(b) *Equation 1:* $TiO_2 + 2C + Cl_2 \rightarrow TiCl_4 + 2CO$
(1) *C +* Cl_2
(1) *balance*
or + $C \rightarrow CO_2$

Equation 2: $TiCl_4 + 4Na$ (*or 2Mg)* $\rightarrow$ 4NaCl (*or* $2MgCl_2$) + Ti 4
(1) *for Na with* $TiCl_4$ *or Mg*
(1) *for balance*

(c) *Extraction*: form metal oxide **(1)**
Or metal oxide implied

reduce **or** react with suitable reducing agent **(1)**
Consequential on formation of metal oxide

Pollution problems: SO_2 **(1)** or oxides of S not SO_3 alone
(allow any sensible and correct reducing agent identified)

any mention of acid rain
or H_2SO_4
or erosion caused by acid rain
or correct problem due to acid rain **(1)** 4

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9. (a) electrons transferred **(1)** 1

OR some lose e^-, some gain e^-s
OR oxidation is loss of e^-
OR reduction is gain of e^-

(b) (i) *Equation*: $TiO_2 + 2C + 2Cl_2 \rightarrow TiCl_4 + 2CO$ balance **(1)**
or $TiO_2 + C + 2Cl_2 \rightarrow TiCl_4 + CO_2$,
C + Cl_2 ***(1)***
balance ***(1)***

Oxidising agent: Cl_2 **(1)**
Con = 0 marks if more than (species)

Reducing agent: C **(1)**
allow coke, not coal

(ii) *Equation*: $TiCl_4 + 4Na / 2Mg \rightarrow Ti + 4NaCl / 2MgCl_2$
Na/Mg ***(1)***
Balance ***(1)***

Condition 1: high temp **(1)** (500 – 1000)

Explanation: to speed up reaction **(1)**
OR otherwise too slow OR makes more reactants with $E>E_a$

Condition 2: Argon **(1)**
NOT inert atmosphere but mark

Explanation: prevents oxidation of Mg / Na / Ti **(1)** 10
OR prevents contamination of Ti with O/N
OR prevents H_2O reacting with $TiCl_4$ / Na / Mg

(c) electrolysis / electricity is expensive **(1)** 1
OR large energy cost to reduce Al_2O_3

[12]

10. (i) Extraction by C reduction of oxide
Iron **(1)**

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ **(1)**

Extraction by electrolysis
Aluminium **(1)**

$Al^{3+} + 3e^{-} \rightarrow Al$ **(1)**

Extraction by metal displacement
Titanium **(1)**

$TiCl_4 + 4Na \rightarrow Ti + 4NaCl$

or $TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$ **(1)** 6

(ii) The reactive metal must first be extracted **(1)**

This extraction will require a great deal of energy or electrolysis **(1)** 2

(iii) $Be_2C + 4H_2O \rightarrow 2Be(OH)_2 + CH_4$ 2
Species (1)
Balanced (1)

[10]

11. (a) Limestone (or $CaCO_3$) 1
Removes SiO_2 1
$CaCO_3 \rightarrow CaO + CO_2$ 1
$CaO + SiO_2 \rightarrow CaSiO_3$ 1
Removed as slag 1

(b) Dissolve in molten cryolite 1
Electrolyse 1
Carbon electrodes 1
$Al^{3+} + 3e^{-} \rightarrow Al$ 1
$2O^{2-} \rightarrow O_2 + 4e^{-}$ 1

Consumes less energy which is expensive 1
Separation of pure aluminium from scrap (or collection) costs 1

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12. (a) (i) $C + CO_2 \rightarrow 2CO$
(or $2C + O_2 \rightarrow 2CO$, or carbon reduction of an iron oxide) 1

(ii) $3CO + Fe_2O_3 \rightarrow 3CO_2 + 2Fe$ 1

(iii) CO is gaseous (or C is solid) 1
CO has more collisions (or C has very few collisions) 1

(b) Titanium carbide is stable. 1

(c) Cost of chlorine or sodium (or Mg) or argon or batch process (cost is QL mark) 1
Mention of another of these 1

[7]

13.	(a)		Electron donor;		1
	(b)		CO (or C);		1
			$3CO + Fe_2O_3 \rightarrow 3CO_2 + 2Fe$ (or correct equations with carbon);		1
	(c)		Na (or Mg);		1
			Argon;		1
			Na (or Mg or $TiCl_4$) reacts with air (or oxygen or water) (or impurities of O or N in Ti);		1
	(d)	(i)	cryolite;		1
			Molten (or liquid or solution);		1
		(ii)	$Al^{3+} + 3e^{-} \rightarrow Al$;		1
					[9]
14.	(a)		energy comes from combustion of coke/ C *(not coal)*		1
			(allow this mark if stated that the $C + O_2 \rightarrow CO_2$ reaction is exothermic)		
			air blown in *(not oxygen)*		1
			$C + O_2 \rightarrow CO_2$		1
			$CO_2 + C \rightarrow 2CO$		1
			$Fe_2\,O_3$ **(1)** + $3CO \rightarrow 2Fe + 3CO_2$		1
			the carbon dioxide released contributes to global warming (or CO is toxic) (or slag is an eyesore)		1
			limestone is used to remove silicon dioxide / impurities		1
			as slag *(or stated under equation)*		1
			$CaCO_3 \rightarrow CaO + CO_2$		1
			$CaO + SiO_2 \rightarrow CaSiO_3$		1
			(combination of these two equations gains 2 marks)		
					[10]
15.	(a)		Batch process involves stopping and starting		1
			Energy lost when cools down after stopping or energy needed to heat up each time		1
	(b)		$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$	use of C or CO	1
				balance	1
			or $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$		
			or $2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$		
	(c)		$Ti\,O_2 + 2C + 2Cl_2 \rightarrow Ti\,Cl_4 + 2CO$	use of C and Cl_2	1
				balance	1
			or $Ti\,O_2 + C + 2Cl_2 \rightarrow Ti\,Cl_4 + CO_2$		
			$Ti\,Cl_4 + 4Na \rightarrow Ti + 4\,NaCl$	use of Na or Mg	1
			or $Ti\,Cl_4 + 2Mg \rightarrow Ti + 2Mg\,Cl_2$	balance	1
	(d)		Na (or Mg) is expensive or Cl_2 is expensive		1
	(e)		Expensive electricity needed in electrolysis		1
					[10]