

## 2.7 EXTRA QUESTIONS MS

- 1.**
- (a)  $\text{C} + \text{Cl}_2$  (or in eq<sup>n</sup>) (1)  
 heat or 500–1000°C (1) 2
- (b) electrolysis (1)  
 molten or with cryolite (1) 2
- [4]**
- 2.** *Equation(s) for iron*  $\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 2\text{Fe} + 3\text{CO}$  (1)  
 (3CO) (3CO<sub>2</sub>)  
or  $\text{Fe}_3\text{O}_4$   
*Equation(s) for aluminium*  $\text{Al}^{3+} + 3\text{e} \rightarrow \text{Al}$  (1)  
 $\text{O}^{2-} \rightarrow \frac{1}{2} \text{O}_2 + 2\text{e}$  (1) 3
- [7]**
- 3.** Na or Mg (1)  
 Heat (500–1000°C) (1) Ar or inert atmos (1)  
 $\text{TiCl}_4 + 4\text{Na}$  (2Mg)  $\rightarrow \text{Ti} + 4\text{NaCl}$  (2 MgCl<sub>2</sub>) (1) 4
- [4]**
- 4.** (a) (i) *Stage 1*  $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$  (1)  
*Stage 2*  $\text{CO}_2 + \text{C} \rightarrow 2 \text{CO}$  (1)
- (ii) *Equation for carbon*  $\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 2 \text{Fe} + 3\text{CO}$  (1)  
 or  $2\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 4\text{Fe} + 3\text{CO}_2$   
*Equation for carbon monoxide*  $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2 \text{Fe} + 3\text{CO}_2$  (1)
- (iii) *Impurity*  $\text{SiO}_2$  (1)  
*Equation*  $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$  (1)  
 $\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3$  (1) 7
- (b) *Gas*  $\text{CO}_2$  (1)  
*Environmental problem* Global warming (1) 2
- (c) *Gas*  $\text{SO}_2$  (1)  
*Environmental problem* Acid rain (1) 2
- [11]**

5. (a)  $\text{TiO}_2 + 2\text{C} + 2\text{Cl}_2 \longrightarrow \text{TiCl}_4 + 2\text{CO}$   
 Correct species (1)  
 Correctly balanced (1) 2
- (b) *Reducing agent* Na or Mg (1)  
*Conditions* Heat (1)  
 Inert atmosphere or argon (1)  
*Equation*  $\text{TiCl}_4 + 4\text{Na} \longrightarrow \text{Ti} + 4\text{NaCl}$  (1)  
 or  $\text{TiCl}_4 + 2\text{Mg} \longrightarrow \text{Ti} + 2\text{MgCl}_2$  4
- (c) Titanium carbide formed (1) 1

[7]

6. *Transfer marks between section of this question*

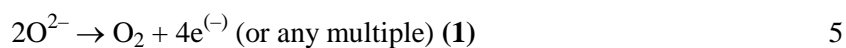
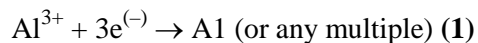
- (a) **Aluminum** Electrolysis (not electricity) of melt or implied (1)

*If both  $\text{Al}_2\text{O}_3$  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*

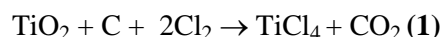


*If aqueous solution given allow max 2 (i.e. for carbon electrodes and equation giving O2)*

*If aqueous only in equations, penalise only the equation for Al extraction*

**Titanium** Oxide converted to chloride using C and  $\text{Cl}_2$  (Q of L mark) (1)

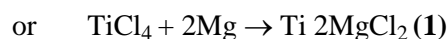
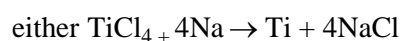
*Note;- oxide ores are rutile and ilmenite*



$\text{TiCl}_4$  purified by distillation (1)

$\text{TiCl}_4$  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)*



*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 Al 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 amount Al (1)

**Titanium** (Only) TiC or name formed when  $\text{TiO}_2$  reacts with C

or  $\text{TiO}_2$  cannot be reduced by C (1)

*Allow TiC from an incorrect equation provided it starts with  $\text{TiO}_2$  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  $\text{Al}_2\text{O}_3$ ) (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  $\text{Al}_2\text{O}_3$ , less holes

or less red mud waste

or Al or fluoride or cryolite toxicity/health risk (1)

*Do not allow cheaper or less expensive*

3

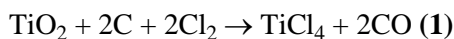
7. (a) (TiO<sub>2</sub>) treated with Cl<sub>2</sub> (1)  
and C (coke) (1)

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

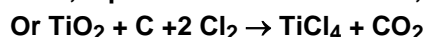
at high temperature (1)

**If specific temperature mentioned allow between 500 to 1000°C**

TiCl<sub>4</sub> formed (1)

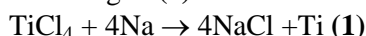


**Note, equation can also score C, Cl<sub>2</sub> and TiCl<sub>4</sub> marks**



(TiCl<sub>4</sub> reacts with) Na or (Mg) (1)

under argon (1)



**Note this equation also scores the Na mark**

Energy for TiO<sub>2</sub> conversion into TiCl<sub>4</sub> expensive

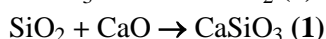
Raw materials in reduction of TiCl<sub>4</sub> expensive (or Na or Cl<sub>2</sub> expensive) (1)

Precautions to keep TiCl<sub>4</sub> dry (or prevent hydrolysis) expensive (1)

Batch process (expensive) (1)

max 11

- (b) (In blast furnace) add limestone (or CaCO<sub>3</sub>) (1)



**or mark 2 for combined equation  $\text{CaCO}_3 + \text{SiO}_2 \rightarrow \text{CaSiO}_3 + \text{CO}_2$**

**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**)

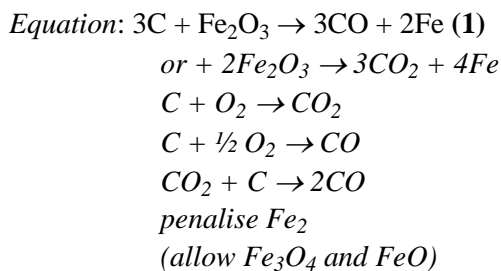
Less CO<sub>2</sub> released into atmosphere (hence greenhouse effect)

(compared with extraction) (1)

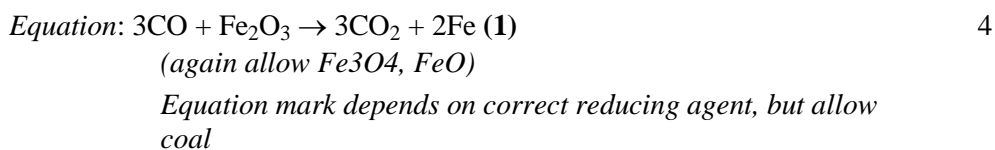
Max 6

[21]

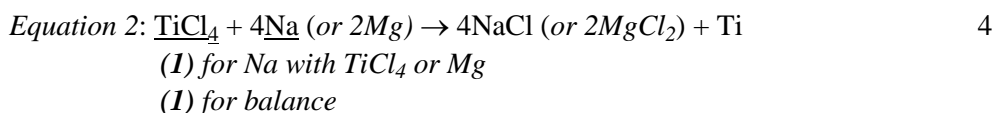
8. (a) Reducing agent 1: C(1) (or coke)  
*Not coal*



Reducing agent 2: CO (1)



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



- (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

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)  
 $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$  (1)  
Extraction by electrolysis  
Aluminium (1)  
 $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$  (1)  
Extraction by metal displacement  
Titanium (1)  
 $\text{TiCl}_4 + 4\text{Na} \rightarrow \text{Ti} + 4\text{NaCl}$   
or  $\text{TiCl}_4 + 2\text{Mg} \rightarrow \text{Ti} + 2\text{MgCl}_2$  (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)  $\text{Be}_2\text{C} + 4\text{H}_2\text{O} \rightarrow 2\text{Be}(\text{OH})_2 + \text{CH}_4$  2  
*Species (1)*  
*Balanced (1)*

[10]

11. (a) Limestone (or  $\text{CaCO}_3$ ) 1  
Removes  $\text{SiO}_2$  1  
 $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$  1  
 $\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3$  1  
Removed as slag 1
- (b) Dissolve in molten cryolite 1  
Electrolyse 1  
Carbon electrodes 1  
 $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$  1  
 $2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^-$  1  
Consumes less energy which is expensive 1  
Separation of pure aluminium from scrap (or collection) costs 1

[12]

12. (a) (i)  $\text{C} + \text{CO}_2 \rightarrow 2\text{CO}$   
(or  $2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$ , or carbon reduction of an iron oxide) 1
- (ii)  $3\text{CO} + \text{Fe}_2\text{O}_3 \rightarrow 3\text{CO}_2 + 2\text{Fe}$  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
		$3\text{CO} + \text{Fe}_2\text{O}_3 \rightarrow 3\text{CO}_2 + 2\text{Fe}$ (or correct equations with carbon);		1
	(c)	Na ( or Mg);		1
		Argon;		1
		Na (or Mg or $\text{TiCl}_4$ ) reacts with air ( or oxygen or water)		1
		( or impurities of O or N in Ti);		1
	(d)	(i) cryolite;		1
		Molten (or liquid or solution);		1
		(ii) $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$ ;		1
				<b>[9]</b>
14.	(a)	energy comes from combustion of coke/ C ( <i>not coal</i> )		1
		( <i>allow this mark if stated that the <math>\text{C} + \text{O}_2 \rightarrow \text{CO}_2</math> reaction is exothermic</i> )		
		<u>air</u> blown in ( <i>not oxygen</i> )		1
		$\text{C} + \text{O}_2 \rightarrow \text{CO}_2$		1
		$\text{CO}_2 + \text{C} \rightarrow 2\text{CO}$		1
		$\text{Fe}_2\text{O}_3$ ( <b>1</b> ) + $3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$		1
		the carbon dioxide released contributes to global warming (or CO is toxic)		1
		(or slag is an eyesore)		
		limestone is used to remove silicon dioxide / impurities		1
		as slag ( <i>or stated under equation</i> )		1
		$\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$		1
		$\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3$		1
		( <i>combination of these two equations gains 2 marks</i> )		
				<b>[10]</b>
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)	$\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 2\text{Fe} + 3\text{CO}$	use of C or CO	1
		or $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$	balance	1
		or $2\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 4\text{Fe} + 3\text{CO}_2$		
	(c)	$\text{TiO}_2 + 2\text{C} + 2\text{Cl}_2 \rightarrow \text{TiCl}_4 + 2\text{CO}$	use of C and $\text{Cl}_2$	1
		or $\text{TiO}_2 + \text{C} + 2\text{Cl}_2 \rightarrow \text{TiCl}_4 + \text{CO}_2$	balance	1
		$\text{TiCl}_4 + 4\text{Na} \rightarrow \text{Ti} + 4\text{NaCl}$	use of Na or Mg	1
		or $\text{TiCl}_4 + 2\text{Mg} \rightarrow \text{Ti} + 2\text{MgCl}_2$	balance	1
	(d)	Na (or Mg) is expensive or $\text{Cl}_2$ is expensive		1
	(e)	Expensive electricity needed in electrolysis		1
				<b>[10]</b>