

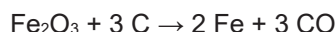
All questions are for separate science students only

Q1.

This question is about displacement reactions.

Iron is extracted from iron oxide by a displacement reaction with carbon.

The equation for the reaction is:



- (a) Which substance in the equation is reduced?

Reduction = loss of oxygen

Give **one** reason for your answer.

Answer in terms of oxygen.

Substance reduced Fe₂O₃

Reason Fe₂O₃ has lost oxygen

(2)

- (b) Which expression shows how to calculate the mass of carbon needed to produce 1 mole of iron from iron oxide?

Relative atomic mass (A_r): C = 12



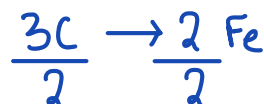
Tick (✓) **one** box. (HT only)

$$\frac{1}{3} \times 12 \text{ g}$$

$$\frac{3}{2} \times 12 \text{ g}$$

$$1 \times 12 \text{ g}$$

$$3 \times 12 \text{ g}$$



$\frac{3}{2}$ moles of C produce 1 mole of Fe

(1)

($A_r \text{ C} = 12$) 1 mole of C has a mass of 12g

$$\text{Mass of } \frac{3}{2} \text{ mole of C} = \frac{3}{2} \times 12 \text{ g}$$

3.3 Yield and Atom Economy of Chemical Reactions (H)

A student investigated displacement reactions of four different metals represented by **A**, **B**, **C** and **D**.

A, **B**, **C** and **D** are **not** the actual chemical symbols for the metals.

The student:

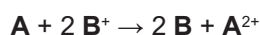
- added each metal to aqueous solutions of the metal nitrates
- observed whether a reaction took place.

The table below shows information about three of the reaction mixtures.

Reaction	Metal	Metal nitrate solution	Equation
1	A	BNO_3	$\text{A} + 2\text{BNO}_3 \rightarrow 2\text{B} + \text{A}(\text{NO}_3)_2$
2	C	$\text{A}(\text{NO}_3)_2$	$2\text{C} + 3\text{A}(\text{NO}_3)_2 \rightarrow 3\text{A} + 2\text{C}(\text{NO}_3)_3$
3	C	$\text{D}(\text{NO}_3)_2$	no reaction

A more reactive than B
C " " " A
D " " " C

(c) The ionic equation for **Reaction 1** is:



Why is this a redox reaction? (HT only)

Redox = Reduction and Oxidation

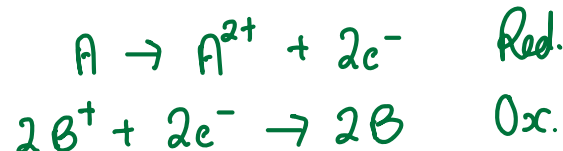
Tick (✓) **one** box.

A gains electrons and **B**⁺ loses electrons.

A loses ✓ electrons and **B**⁺ gains ✓ electrons.

Both **A** and **B**⁺ gain electrons.

Both **A** and **B**⁺ lose electrons.



(1)

(d) Which of the four metals has the **greatest tendency to form positive ions**?

Use the table above.

D > C > A > B

Tick (✓) **one** box.

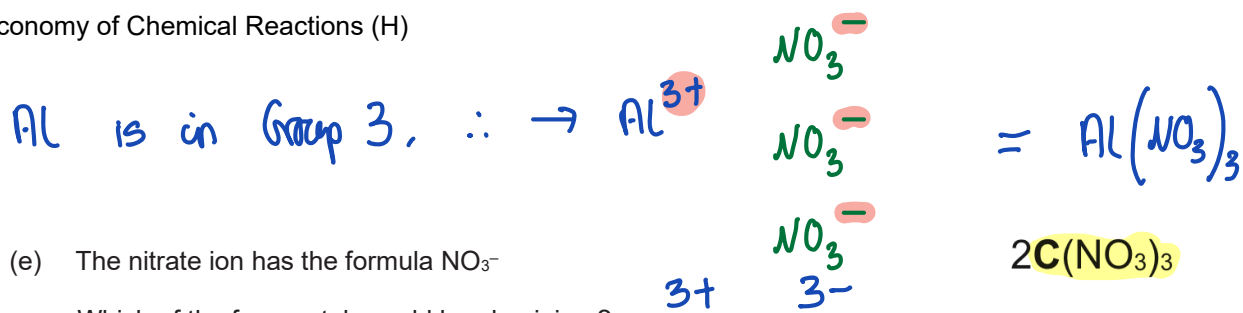
A

B

C

D

(1)



Which of the four metals could be aluminium?

Explain your answer.

Use the table above.

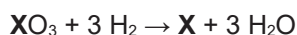
Metal C

Explanation Al forms ions with a charge 3+
So, 3 NO_3^- ions are needed to balance
the charge on 1 Al ion.

(3)

(f) Metal X is extracted from an oxide of metal X by reaction with hydrogen.

The equation for the reaction is:



The percentage atom economy for obtaining metal X by this method is 77.3%.

Calculate the relative atomic mass (A_r) of metal X. (chemistry only)

Relative atomic masses (A_r): H = 1 O = 16

$$\% \text{ Atom Economy} = \frac{\text{Mass of desired product}}{\text{Mass of all products}} \times 100$$

$$77.3 = \frac{X}{X + 3\text{H}_2\text{O}} \times 100$$

$$\frac{77.3}{100} = \frac{X}{X + (3 \times 18)}$$

Relative atomic mass (A_r) = 184

(4)

(Total 12 marks)

$$0.773 (X + 54) = X$$

$$0.773 X + 41.742 = X$$

$$41.742 = X - 0.773 X$$

$$41.742 = 0.227 X$$

$$X = \frac{41.742}{0.227}$$

$$X = 183.89$$