Unit 10 · Metallurgy

HARDER PRACTICE QUESTIONS

Full marks 42

Write your answers on separate paper. Show your working. H = 1, C = 12, O = 16, Al = 27, Si = 28, Ca = 40, Fe = 56, Cu = 63.5, Ag = 108. Molar volume at STP = 22.4 L.

1 Spot the errors [3]

Find the two mistakes and correct them.

Kopila was asked how much iron 1,000 kg of ore holding 50% hematite can give, and how much carbon monoxide it needs. She wrote:
"Fe_2O_3 = 500 kg. Iron is 56/160 of Fe_2O_3, so 500 × 56 ÷ 160 = **175 kg** of iron. The equation is $Fe_2O_3 + CO \rightarrow 2Fe + CO_2$, so 1 mol CO for each mole of Fe_2O_3."

2 Five metals, three tests [5]

Arjun has five metal pieces, A to E: one each of iron, copper, aluminium, silver and gold. He puts each in three liquids.

Metal	Dilute HCl	Dilute HNO_3	Aqua regia
A	nothing at first, then fast bubbles; colorless	slow reaction	dissolves
B	bubbles; pale green solution	dissolves	dissolves
C	no reaction	blue solution, brown fumes at the mouth	dissolves
D	no reaction	colorless solution	a white skin forms; stops
E	no reaction	no reaction	yellow solution

i. Name A to E.
ii. Write the equation for B with dilute HCl.
iii. Explain the brown fumes over C.
iv. Why does D stop in aqua regia, though it dissolves in nitric acid?

3 Which rock? [4]

Three mines offer rock. Rock P is 50% hematite (Fe_2O_3), rock Q 40% magnetite (Fe_3O_4), rock S 90% siderite ($FeCO_3$); the rest is gangue.

i. Find the mass of iron in a tonne (1,000 kg) of each.
ii. Which rock gives the most iron?
iii. Which mineral is the richest in iron?
iv. Give one reason, other than iron content, why iron pyrites is not used, though it is a common mineral.

4 Work backward [4]

Bibisha adds 8.3 g of a mixture of aluminium and iron powders to excess dilute hydrochloric acid, and collects 5.6 L of hydrogen at STP. Find the mass of each metal.

5 How many carats? [4]

A bangle of gold mixed with copper has a mass of 23.3 g and a volume of 1.30 cm^3. Suppose the volumes of the two metals simply add. Gold is 19.3 g/cm^3, copper 8.93 g/cm^3.

i. Find the bangle's density.
ii. If g grams of the bangle are gold, write the volume of gold and of copper in terms of g.
iii. Find g.
iv. About what carat is the bangle?

6 Which explanation fits the evidence? [3]

Pratik: "Aqua regia dissolves gold because it is simply a stronger acid than either acid alone."
Kriti: "Nitric acid takes a few electrons from gold, and the chloride from the hydrochloric acid holds the gold ions as $AuCl_4^-$, so more gold keeps dissolving."
Silver dissolves in nitric acid alone but stops in aqua regia. Gold dissolves in neither acid alone. Decide between them, using both facts.

7 What if? [3]

Predict what would go wrong in the blast furnace, and explain, if:

i. no limestone were added;
ii. the ore were not calcined, and held iron(II) oxide;
iii. the slag were heavier than the iron.

8 Count the electrons [3]

For $3Ag + 4HNO_3 \rightarrow 3AgNO_3 + NO + 2H_2O$:

i. Show that the electrons given equal the electrons taken.
ii. How many of the four nitrate groups don't change?
iii. What volume of NO at STP comes from 10.8 g of silver?

9 Choose the metal [3]

For each job, choose one of iron, copper, aluminium, silver and gold, and give the property that decides it. No metal twice.

i. the contacts inside a phone
ii. the core of an electromagnet
iii. the wires of an overhead power line between towers

10 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

Lhamu wrote: "In the blast furnace the coke reduces the iron ore directly, in the zone of reduction at the bottom, the hottest part. The iron that comes out, pig iron, is soft and easily hammered."

11 Estimate [3]

A new plant reduces iron ore with hydrogen instead of carbon monoxide: $Fe_2O_3 + 3H_2 \rightarrow 2Fe + 3H_2O$. For every tonne (1,000 kg) of iron, estimate:

i. the mass of hydrogen needed;
ii. the mass of water given off;
iii. the mass of CO_2 a blast furnace would give off from the reduction alone, $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$.

12 Think [2]

Gold can be beaten into leaf about a ten-thousandth of a millimeter thick. One tola (11.66 g) of gold has a volume of 0.604 cm^3. About how much area could a tola of gold cover?

13 Make your own [2]

Write a question about one of the five metals that needs both a fact from 10.3 (a property) and one from 10.4 (a reaction with an acid). Give the answer.