

GCSE / IGCSE Chemistry – Chemical Changes and Energy

GCSE / IGCSE (Edexcel / Cambridge style) · Total marks: 37 · Answers on the last page

This worksheet covers the reactivity series, acids and bases, electrolysis and energy changes. Use the relative atomic masses given in each question (rounded to whole numbers, as used at GCSE/IGCSE level); a calculator is allowed.

Section A – Reactivity and Acids/Bases (Skills)

1. Place the following metals in order of reactivity, most reactive first: copper, magnesium, zinc, iron. [2]
2. Write the balanced symbol equation, including state symbols, for the reaction between magnesium and dilute hydrochloric acid. [3]
3. Define "neutralisation" and write the balanced symbol equation for the reaction between sodium hydroxide and sulfuric acid. [3]
4. Calculate the relative formula mass (M_r) of calcium carbonate, CaCO_3 . (A_r : Ca = 40, C = 12, O = 16) [2]

Section B – Electrolysis and Energy Changes (Exam-style)

5. Explain, using ionic half-equations, what happens at each electrode during the electrolysis of molten lead(II) bromide, PbBr_2 . [4]
6. Explain why aluminium is extracted by electrolysis rather than by reduction with carbon. [2]
7. In an experiment, 50 cm^3 of dilute hydrochloric acid at 20.0°C was reacted with excess magnesium ribbon. The maximum temperature reached was 34.5°C . Calculate the temperature change, and state whether the reaction is exothermic or endothermic. [2]
8. Using the temperature change in the previous question, calculate the energy change in joules, given the specific heat capacity of the solution is $4.2\text{ J/g}^\circ\text{C}$ and the mass of solution is 50 g. [3]

Section C – Extended / Challenge

9. A student carries out an electrolysis experiment using a copper sulfate solution to electroplate a metal spoon with copper.
(a) State which electrode, anode or cathode, the spoon should be, and explain why.
(b) Write the half-equation for the reaction occurring at the copper anode used in electroplating. [4]
10. Using bond energies, calculate the overall enthalpy change for the reaction $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$, given: bond energy H–H = +436 kJ/mol, Cl–Cl = +243 kJ/mol, H–Cl = +432 kJ/mol. [4]
11. Calculate the percentage of aluminium by mass in aluminium oxide, Al_2O_3 . (A_r : Al = 27, O = 16) [3]
12. A displacement reaction occurs when zinc granules are added to copper(II) sulfate solution.
(a) Write the balanced symbol equation for this reaction.

(b) Explain, in terms of electron transfer, why this is a redox reaction, identifying which species is oxidised and which is reduced. [5]

Answers

Check your working against these. If an answer does not match, try the question again before looking for the method.

1. Magnesium, zinc, iron, copper (most to least reactive).
2. $\text{Mg}(s) + 2\text{HCl}(aq) \rightarrow \text{MgCl}_2(aq) + \text{H}_2(g)$
3. Neutralisation is the reaction between an acid and a base in which they react to form a salt and water. $2\text{NaOH}(aq) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{Na}_2\text{SO}_4(aq) + 2\text{H}_2\text{O}(l)$
4. $M_r = 40 + 12 + (3 \times 16) = 40 + 12 + 48 = 100$.
5. At the cathode (negative electrode), Pb^{2+} ions are reduced (gain electrons) to form lead metal: $\text{Pb}^{2+} + 2e^- \rightarrow \text{Pb}$. At the anode (positive electrode), Br^- ions are oxidised (lose electrons) to form bromine: $2\text{Br}^- \rightarrow \text{Br}_2 + 2e^-$.
6. Aluminium is more reactive than carbon, so carbon cannot remove the oxygen from (reduce) aluminium oxide. Electrolysis of molten aluminium oxide (dissolved in molten cryolite to lower its melting point) is used instead to separate the aluminium and oxygen.
7. $\Delta T = 34.5 - 20.0 = 14.5^\circ\text{C}$ (a rise). The reaction is exothermic, since the temperature increases as energy is released to the surroundings.
8. $Q = mc\Delta T = 50 \times 4.2 \times 14.5 = 3045 \text{ J}$ (3.045 kJ).
9. (a) The spoon should be the cathode (negative electrode), so that positively charged Cu^{2+} ions in the solution are attracted to it and are reduced (gain electrons) to deposit as a layer of copper metal on its surface.
(b) At the copper anode: $\text{Cu}(s) \rightarrow \text{Cu}^{2+}(aq) + 2e^-$ (the copper anode dissolves, releasing copper ions into solution).
10. Energy to break bonds = $436 + 243 = 679 \text{ kJ/mol}$. Energy released forming bonds = $2 \times 432 = 864 \text{ kJ/mol}$. $\Delta H = 679 - 864 = -185 \text{ kJ/mol}$ (exothermic).
11. $M_r(\text{Al}_2\text{O}_3) = (2 \times 27) + (3 \times 16) = 54 + 48 = 102$. Percentage Al = $\frac{54}{102} \times 100 = 52.9\%$ (3 s.f.).
12. (a) $\text{Zn}(s) + \text{CuSO}_4(aq) \rightarrow \text{ZnSO}_4(aq) + \text{Cu}(s)$
(b) Zinc atoms lose electrons to form Zn^{2+} ions (oxidation), while Cu^{2+} ions gain electrons to form copper atoms (reduction). Since oxidation and reduction both occur, this is a redox reaction.

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