11. Group 17

11.4 The reactions of chlorine

Paper 1

Question Paper

1 The name 'chlorate' is used for an anion consisting of chlorine and oxygen only.

In a molecule of ICl, the iodine atom has oxidation number *x* and the chlorine atom has oxidation number *y*.

When ICl is added to H_2O, iodine is reduced.

$$4ICl + 2H_2O \rightarrow 4HCl + O_2 + 2I_2$$

Which statement about the value of *x* or *y* is correct?

A *x* is the same as the oxidation number of Cl in the chlorate ion formed when Cl_2(aq) is added to cold NaOH(aq).

B *x* is the same as the oxidation number of Cl in the chlorate ion formed when Cl_2(aq) is added to hot NaOH(aq).

C *y* is the same as the oxidation number of Cl in the chlorate ion formed when Cl_2(aq) is added to cold NaOH(aq).

D *y* is the same as the oxidation number of Cl in the chlorate ion formed when Cl_2(aq) is added to hot NaOH(aq).

2 In reaction 1, concentrated sulfuric acid is added to potassium chloride and the fumes produced are bubbled into aqueous potassium iodide solution.

In reaction 2, potassium chloride is dissolved in aqueous ammonia and this is then added to aqueous silver nitrate.

What are the observations for reactions 1 and 2?

	observation for reaction 1	observation for reaction 2
A	brown solution	colourless solution
B	brown solution	white precipitate
C	colourless solution	colourless solution
D	colourless solution	white precipitate

3 A solid sodium halide, NaX, is reacted with concentrated sulfuric acid. The **lowest** oxidation state of sulfur in the products is +4.

Halogen Y_2 is less volatile than halogen X_2.

What are the identities of sodium halide NaX and halogen Y_2?

	sodium halide NaX	halogen Y_2
A	sodium bromide	chlorine
B	sodium bromide	iodine
C	sodium iodide	bromine
D	sodium iodide	astatine

4 Chlorine gas is reacted with cold aqueous sodium hydroxide.

Which statement is correct for this reaction?

A Chlorine is both oxidised and reduced.

B Chlorine is neither oxidised nor reduced.

C Chlorine is oxidised but not reduced.

D Chlorine is reduced but not oxidised.

5 HOCl(aq) is the molecule that kills bacteria when chlorine is added to water.

The following reaction produces this molecule.

$$Cl_2(g) + H_2O(l) \rightleftharpoons HOCl(aq) + H^+(aq) + Cl^-(aq)$$

Which statement about this reaction is correct?

A Chlorine is both oxidised and reduced.

B Chlorine is oxidised but **not** reduced.

C Hydrogen is both oxidised and reduced.

D Hydrogen is oxidised but **not** reduced.

6 Bromine reacts with aqueous sodium hydroxide at 25 °C.

reaction 1 $Br_2(aq) + 2NaOH(aq) \rightarrow NaBr(aq) + NaOBr(aq) + H_2O(l)$

The NaOBr formed is unstable at 25 °C and reacts further.

reaction 2 $3NaOBr(aq) \rightarrow 2NaBr(aq) + NaBrO_3(aq)$

Which reactions are disproportionations?

A both reaction 1 and reaction 2

B neither reaction 1 nor reaction 2

C reaction 1 only

D reaction 2 only

7 Chlorine dioxide, ClO_2, reacts with aqueous sodium hydroxide to produce water and a mixture of two sodium salts, $NaClO_2$ and $NaClO_3$.

What is the mole ratio of $NaClO_2$ to $NaClO_3$ in the product mixture?

A 1 : 2 **B** 3 : 5 **C** 1 : 1 **D** 5 : 3

8 Chlorine is bubbled through 100 cm^3 of hot 4.0 mol dm^{-3} sodium hydroxide until the reaction is complete.

$$6NaOH(aq) + xCl_2(aq) \rightarrow yNaCl(aq) + zNaClO_3(aq) + 3H_2O(l)$$

Which row is correct?

	x	$[Na^+](aq)$ after reaction / mol dm^{-3}
A	3	4.0
B	3	less than 4.0
C	6	4.0
D	6	less than 4.0

9 What is the oxidation state of the chlorine-containing species that kills bacteria in drinking water?

A –1 **B** +1 **C** +3 **D** +5

10 Z is a compound of sodium, chlorine and oxygen.

It contains 45.1% by mass of oxygen.

Z is prepared by reacting sodium hydroxide with chlorine.

Which row shows the conditions used for the reaction and the oxidation state of chlorine in Z?

	reaction conditions	oxidation state of Cl in Z
A	cold dilute NaOH	+1
B	cold dilute NaOH	+5
C	hot concentrated NaOH	+1
D	hot concentrated NaOH	+5

11 Chlorine gas is widely used to treat contaminated water.

When chlorine is added to water, which chemical species present is responsible for killing bacteria?

A ClO_2^- **B** Cl^- **C** HCl **D** ClO^-

12 Most modern cars are fitted with catalytic converters in the exhaust system.

Which three gases are removed by a catalytic converter?

A carbon monoxide, hydrocarbons, nitrogen oxides

B carbon monoxide, carbon dioxide, nitrogen oxides

C carbon monoxide, nitrogen oxides, sulfur dioxide

D hydrocarbons, nitrogen oxides, sulfur dioxide

13 Chlorate(V) ions, ClO_3^-, are produced in the redox reaction between chlorine and hot aqueous sodium hydroxide. Oxidation numbers can be used to help balance the equation for this reaction.

$$vCl_2(g) + wOH^-(aq) \rightarrow xCl^-(aq) + yClO_3^-(aq) + zH_2O(l)$$

What are the values of v, x and y in the balanced equation?

	v	x	y
A	2	3	1
B	3	4	2
C	3	5	1
D	7	12	2

14 The reaction of bromine with warm NaOH(aq) produces products with the same oxidation numbers, in the same ratios, as the reaction of chlorine with hot NaOH(aq).

In one reaction between bromine and warm NaOH(aq), 30.2 g of a product containing sodium, bromine and oxygen is produced.

Which mass of NaOH has reacted?

A 8.00 g **B** 10.2 g **C** 20.3 g **D** 48.0 g

15 X is either chlorine or an oxide of chlorine.

X reacts with water, under suitable conditions, to form the two acids HCl and $HClO_3$ in the mole ratio of 1 (HCl) : 5 ($HClO_3$).

What could be X?

A Cl_2 **B** Cl_2O **C** ClO_2 **D** Cl_2O_7

16 An excess of chlorine was bubbled into 100 cm^3 of hot 6.0 mol dm^{-3} sodium hydroxide.

How many moles of sodium chloride would be produced in the reaction?

A 0.3 **B** 0.5 **C** 0.6 **D** 1.2

17 Reaction 1: chlorine reacts with cold aqueous sodium hydroxide to form solution Z.

Reaction 2: solution Z is heated and forms ClO_3^-(aq) and Cl^-(aq).

Which equations represent reaction 1 and reaction 2?

A reaction 1 $2Cl_2 + 4OH^- \rightarrow ClO_2^- + 3Cl^- + 2H_2O$
reaction 2 $3ClO_2^- \rightarrow 2ClO_3^- + Cl^-$

B reaction 1 $2Cl_2 + 4OH^- \rightarrow ClO_2^- + 3Cl^- + 2H_2O$
reaction 2 $3ClO^- \rightarrow ClO_3^- + 2Cl^-$

C reaction 1 $Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$
reaction 2 $2ClO^- + 2OH^- \rightarrow ClO_3^- + Cl^- + H_2O$

D reaction 1 $Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$
reaction 2 $3ClO^- \rightarrow ClO_3^- + 2Cl^-$

18 Chlorine reacts with both hot and cold sodium hydroxide to form products containing chlorine.

Cold sodium hydroxide forms sodium chlorate(X) and hot sodium hydroxide forms sodium chlorate(Y). X and Y are oxidation numbers.

Which equation is correct?

A Y = X – 6 **B** Y = X – 4 **C** Y = X + 4 **D** Y = X + 6

19 Chlorine reacts with **cold** aqueous sodium hydroxide to produce sodium chloride, water and compound X.

Chlorine reacts with **hot** aqueous sodium hydroxide to produce sodium chloride, water and compound Y.

What are the oxidation states of chlorine in compound X and compound Y?

	X	Y
A	–1	–5
B	–1	+5
C	+1	–5
D	+1	+5