12 $KMnO_4$ is an oxidising agent. Its reaction with Fe^{2+} is shown in the following ionic equation.

$$...X...MnO_4^- + ...Fe^{2+} + ...H^+ \rightarrow .....Mn^{2+} + ...Y...Fe^{3+} + ...H_2O$$

What are X and Y when the equation is balanced?

	X	Y
A	1	1
B	1	3
C	1	5
D	5	1

6 The compound potassium bismuthate(V), $KBiO_3$, is a powerful oxidising agent.

What is the significance of the (V) in potassium bismuthate(V)?

A It is the oxidation number of the bismuth atom.

B It is the charge of the bismuthate ion.

C It is the oxidation number of the bismuthate ion.

D It is the sum of the charges of the two ions present.

12 Chlorine reacts with sodium bromide.

$$\tfrac{1}{2}Cl_2 + NaBr \rightarrow NaCl + \tfrac{1}{2}Br_2$$

Which words correctly describe this reaction?

1 redox

2 displacement

3 disproportionation

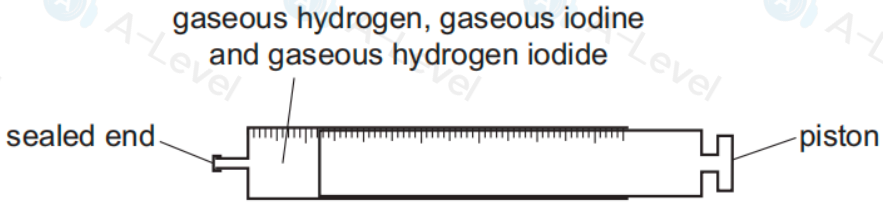
A 1, 2 and 3

B 1 and 2 only

C 1 only

D 2 only

17 The diagram shows a gas syringe with a free-moving piston. The syringe contains gaseous hydrogen, gaseous iodine and gaseous hydrogen iodide at equilibrium.



$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

Three changes are listed.

1 increasing the total pressure by adding an inert gas and keeping the volume constant

2 increasing the pressure by adding more gaseous hydrogen iodide and keeping the volume constant

3 decreasing the volume by pushing the piston to the left

Which changes will result in an equilibrium position at which the rate of the forward reaction has increased?

A 2 only **B** 1 and 2 **C** 1 and 3 **D** 2 and 3

10 In a catalytic converter in the exhaust system of a car, carbon monoxide is oxidised to carbon dioxide, and nitrogen monoxide is reduced to nitrogen.

What are the changes in oxidation number of carbon and nitrogen in these two processes?

	carbon	nitrogen
A	–2	+2
B	–1	+1
C	+1	–1
D	+2	–2

16 Chlorine gas is reacted with aqueous sodium hydroxide. The oxidation number of chlorine changes from 0 to –1 and also from 0 to +1.

Under which conditions does this reaction occur and what is the colour of the solid silver salt with chlorine in the oxidation state –1?

	reaction conditions	colour of silver salt
A	cold, dilute alkali	white
B	cold, dilute alkali	yellow
C	hot, concentrated alkali	white
D	hot, concentrated alkali	yellow

11 NCl_3 reacts with H_2O.

$$NCl_3 + 3H_2O \rightarrow NH_3 + 3HClO$$

The oxidation state of nitrogen does not change in this reaction.

Which statement is correct?

A Chlorine is reduced.

B Chlorine is oxidised.

C Hydrogen is both oxidised and reduced.

D This is not a redox reaction.

10 Two half-equations are shown.

$$MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$$

$$2OH^- + SO_3^{2-} \rightarrow SO_4^{2-} + H_2O + 2e^-$$

The equation for the reaction between manganate(VII) ions and sulfite ions is shown.

$$uMnO_4^- + vH_2O + wSO_3^{2-} \rightarrow xMnO_2 + ySO_4^{2-} + zOH^-$$

Which statements are correct?

1 $u = x = z$

2 Manganese is reduced to oxidation state +4.

3 Sulfur is oxidised from oxidation state +4 to +6.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

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

A –1 **B** +1 **C** +3 **D** +5

12 The vanadium salt, $VOSO_4$, is soluble in water and reacts readily with powdered manganese in dilute sulfuric acid.

The equation for the reaction is shown.

$$Mn(s) + 2VOSO_4(aq) + 2H_2SO_4(aq) \rightarrow V_2(SO_4)_3(aq) + MnSO_4(aq) + 2H_2O(l)$$

Which statement about this reaction is correct?

A Hydrogen is oxidised in the reaction.

B Manganese is the reducing agent in this reaction.

C Sulfuric acid is the oxidising agent in this reaction.

D The oxidation state of the vanadium changes from +5 to +3.

3 Zinc reacts with concentrated nitric acid giving three products only: zinc nitrate, an oxide of nitrogen and water.

3.0 moles of zinc react with 8.0 moles of nitric acid. Zinc nitrate contains Zn^{2+} ions.

What could be the formula of the oxide of nitrogen?

A N_2O **B** NO **C** N_2O_3 **D** NO_2

13 The equation for the reaction between aqueous copper ions and aqueous iodide ions is as follows.

$$2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow 2CuI(s) + I_2(aq)$$

What is the change in oxidation state of copper?

A +2 to –1 **B** +2 to 0 **C** +2 to +1 **D** +4 to +2

23 Chlorine reacts with aqueous sodium hydroxide forming two chlorine-containing products.

Which row shows the oxidation states of chlorine in the products under the conditions stated?

	conditions	oxidation state of C*l* in products
A	cold NaOH(aq)	–1 and +3
B	cold NaOH(aq)	–1 and +5
C	hot NaOH(aq)	–1 and +3
D	hot NaOH(aq)	–1 and +5

24 A catalytic converter reduces the amount of pollutants in the fumes from a car exhaust.

Which row identifies a pollutant and shows how it is removed by the action of the catalyst?

	pollutant	chemical removal
A	carbon dioxide	reduced to carbon
B	carbon monoxide	oxidised to carbon dioxide
C	oxides of nitrogen	oxidised to nitric acid
D	unburnt hydrocarbons	oxidised to carbon dioxide and hydrogen

9 The equation for a redox reaction is shown.

$$SnCl_2(aq) + 2HgCl_2(aq) \rightarrow SnCl_4(aq) + Hg_2Cl_2(s)$$

Which species is being oxidised in this reaction?

A Sn^{2+} **B** Cl^{-} **C** Hg^{+} **D** Hg^{2+}

11 One of the reactions in the rechargeable lead / acid battery is shown.

$$Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

Which statement about this reaction is correct?

A Lead is both oxidised and reduced.

B Lead is neither oxidised nor reduced.

C Lead is oxidised only.

D Lead is reduced only.

12 In which row do the oxidation numbers of vanadium increase?

	smallest →		largest
A	VO_4^{3-}	VO_3^-	VO_2^+
B	VO^{2+}	V_2O_3	VO_4^{3-}
C	V_2O_3	VO^{2+}	VO_3^-
D	VO_4^{3-}	VO_2^+	VO^{2+}

1 Which species contains a different number of electrons from the other three?

A ClO_4^- **B** H_2SO_4 **C** SO_4^{2-} **D** Te^{2-}

17 When concentrated sulfuric acid reacts with sodium iodide the products include sulfur, iodine, hydrogen sulfide and sulfur dioxide.

Which statement is correct?

A Hydrogen sulfide is the product of a reduction reaction.

B Iodide ions are stronger oxidising agents than sulfate ions.

C Sulfur atoms from the sulfuric acid are both oxidised and reduced.

D Sulfur atoms from the sulfuric acid are oxidised to make sulfur dioxide.

18 NO, NO_2, CO and unburnt hydrocarbons are present in the exhaust gases of internal combustion engines. When catalytic converters are used to remove these compounds from the exhaust gases, redox reactions occur.

What happens to each compound in the catalytic converter?

	NO	NO_2	CO	unburnt hydrocarbons
A	oxidised	oxidised	reduced	oxidised
B	oxidised	oxidised	oxidised	oxidised
C	reduced	reduced	oxidised	oxidised
D	reduced	reduced	reduced	reduced

5 Two moles of VO_2^+ ions react with one mole of zinc atoms in the presence of dilute acid. The products include Zn^{2+} ions and an ion, Y. Ion Y contains vanadium. Only zinc and vanadium change oxidation state in the reaction.

What is ion Y?

A VO_3^- **B** VO^+ **C** VO^{2+} **D** VO_2^{2+}

11 Hydrogen peroxide, H_2O_2, decomposes to form water and oxygen.

The reaction is catalysed by bromide ions.

step 1 $2Br^-(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow 2H_2O(l) + Br_2(aq)$

step 2 $H_2O_2(aq) + Br_2(aq) \rightarrow 2Br^-(aq) + 2H^+(aq) + O_2(g)$

Which row is correct?

	type of catalyst	in step 1
A	heterogeneous	bromide ions are oxidised
B	heterogeneous	bromide ions are reduced
C	homogeneous	bromide ions are oxidised
D	homogeneous	bromide ions are reduced

8 VO_2Cl reacts with NaI under acidic conditions.

$$2VO_2Cl + 2H_2SO_4 + 2NaI \rightarrow VOCl_2 + VOSO_4 + I_2 + Na_2SO_4 + 2H_2O$$

The oxidation state of Cl is –1 in VO_2Cl and in $VOCl_2$.

Which row about this reaction is correct?

	vanadium	iodine
A	is oxidised	is oxidised
B	is oxidised	is reduced
C	is reduced	is oxidised
D	is reduced	is reduced

11 $LiAlH_4$ contains AlH_4^- ions in which aluminium has an oxidation state of +3.

$LiAlH_4$ reacts with water, as shown.

$$LiAlH_4 + 4H_2O \rightarrow 4H_2 + LiOH + Al(OH)_3$$

In this reaction, each of the four water molecules produces one hydroxide ion. It does this by losing one H^+ ion, which reacts with the $LiAlH_4$.

Which changes in oxidation number occur in this reaction?

A Al increases by 1 and H decreases by 1.

B H decreases by 2 and also increases by 1.

C H increases by 1 and also decreases by 1.

D O decreases by 1 and H increases by 1.