WJEC QWL Questions in Paper 5.

WJEC CBAC

GCE A level

1095/01

CHEMISTRY – CH5

P.M. TUESDAY, 17 June 2014

1 hour 45 minutes

Years 2014, 2015 and 2016

$+4\ -2$ $+1\ +7\ -2$

MnO_2 . $KMnO_4$

3 *(c)* Manganese(IV) oxide *(line 10)* and potassium manganate(VII) *(lines 20-21)* are typical transition metal compounds.

(i) Give **two** reasons why transition metal compounds can act as catalysts. [2]

+6 -2 2

Cr_2O_7

(+12) -14 = -2

.....

.....

.....

(ii) Explain why transition metal complex ions appear coloured. [4]

QWC [1]

(c) (i) Variable oxidation states / partially filled 3d energy levels /ability to adsorb 'molecules' / form complexes (or temporary bonds) with reacting molecules
(Accept any two answers)
Do not accept 'empty / unfilled d-orbitals' [2]

(ii) 3d orbitals split by ligands (1)

Three d-orbitals have lower energy, two have higher energy (1)

Electrons absorb (visible light) energy to jump from lower level to higher level (1)

The colour is that due to the remaining / non-absorbed frequencies (1)
(Appropriate diagrams are acceptable alternatives)

[4]

QWC *Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning* [1]

HOMO

$$S_2O_8^{2-} + 2I^- = 2SO_4^{2-} + I_2 \quad (\leftarrow 2e^-)$$

$$2Fe^{2+} + S_2O_8^{2-} = 2SO_4^{2-} + 2Fe^{3+}$$

$$2Fe^{3+} + 2I^- = 2Fe^{2+} + I_2$$

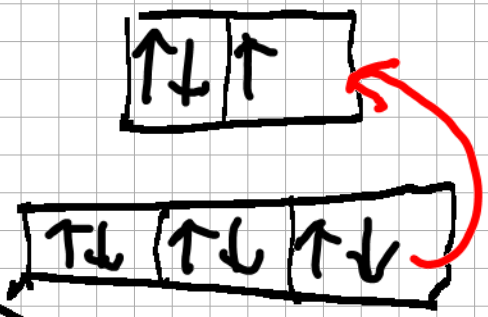
$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Fe cat ADSORB / DESORB.

- Ligands - lone pairs Repulsion

3d subshell

- split 3d atomic orbital (Octahedral 2 over 3)

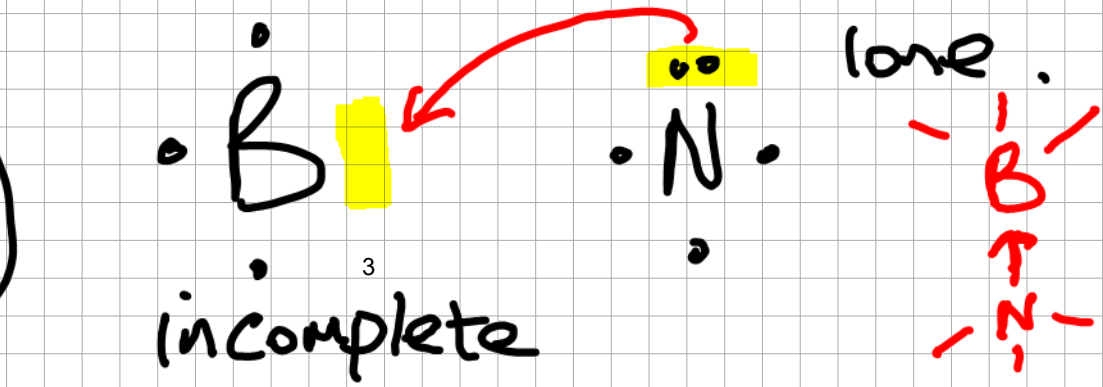


- Complex ions absorbs energy

- Corresponding to wavelengths of light
- for an electron transition
- The Remaining wavelength of light are Reflected
- The chemical then appears coloured

Nitrate NO_3^- nitrite NO_2^-

Nitride ion N^{3-}



incomplete

4 *(b)* Carbon is the first element in Group 4. Two of its allotropes are diamond and graphite. A compound that forms structures corresponding to diamond and graphite is boron nitride.

(i) Describe the structure of graphite and explain why **hexagonal** boron nitride can adopt the same structure yet have different electrical conductivity properties. [4]

QWC [1]

(b) (i) Each C atom covalently bonded to three other C atoms forming layers (1)

Layers held together by weak intermolecular forces (1)

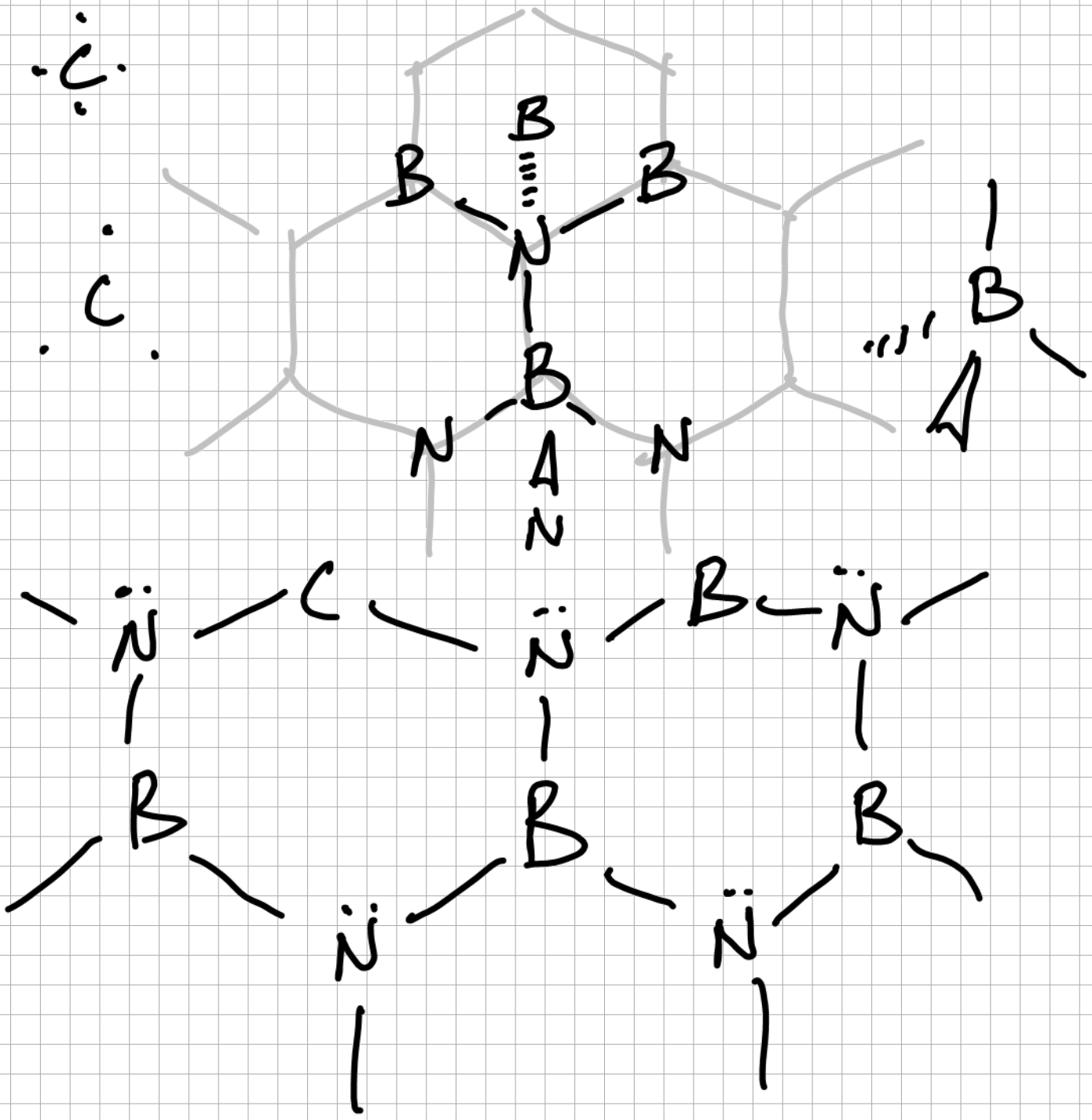
BN is isoelectronic with C so it forms similar structures (1) *

Graphite conducts electricity since electrons are delocalised but in BN, each N has a full unbonded p-orbital and each B has an empty unbonded p-orbital so it does not conduct electricity (1) [4]

(Accept electrons are not delocalised in BN so it does not conduct electricity)

QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate [1]

ISO = Same



5. *(a)* Chlorine reacts with aqueous sodium hydroxide in one of two ways, depending on the temperature used.

(i) Write the equation for the reaction of chlorine with

I cold aqueous sodium hydroxide, [1]

II hot aqueous sodium hydroxide. [1]

(ii) Classify this type of redox reaction. [1]

(b) Chlorine reacts with many elements to form chlorides. Explain why phosphorus forms two chlorides, PCl_3 and PCl_5, but nitrogen only forms NCl_3. [2]

(c) Most ionic chlorides, e.g. sodium chloride, are soluble in water. However some, e.g. silver chloride, are insoluble.

The enthalpy change of solution of an ionic compound and its solubility depend on the balance between two enthalpy changes. Name these enthalpy changes and state if they are endothermic or exothermic. Explain how the enthalpy change of solution of a compound and its solubility depend on the balance between them. [4]

QWC [1]

Q.5 (a) (i) Cold $Cl_2 + 2NaOH \longrightarrow NaCl + NaClO + H_2O$ (1)

Warm $3Cl_2 + 6NaOH \longrightarrow 5NaCl + NaClO_3 + 3H_2O$ (1)

[2]

(ii) Disproportionation [1]

(b) P can (extend the normal octet of electrons) by using 3d orbitals /
P can promote 3s electron to 3d orbital (1)
N cannot do this since it is in the second period / 3d orbitals not available (1)
[2]

(c) The terms involved are: lattice breaking enthalpy which is endothermic (1)

and hydration enthalpy which is exothermic (1)

ΔH solution = ΔH lattice breaking + ΔH hydration (or similar) (1)

If ΔH solution is negative then the ionic solid will be soluble (1)

[4]

QWC Selection of a form and style of writing appropriate to purpose and to complexity of subject matter [1]

Chlorine

- reacts with cold and dilute sodium hydroxide solution to form sodium chloride and sodium chlorate(I) (also called sodium hypochlorite)

$$\underset{0}{Cl_2(aq)} + 2NaOH(aq) \longrightarrow \underset{-1}{NaCl(aq)} + \underset{+1}{NaOCl(aq)} + H_2O(l)$$

cold, dilute

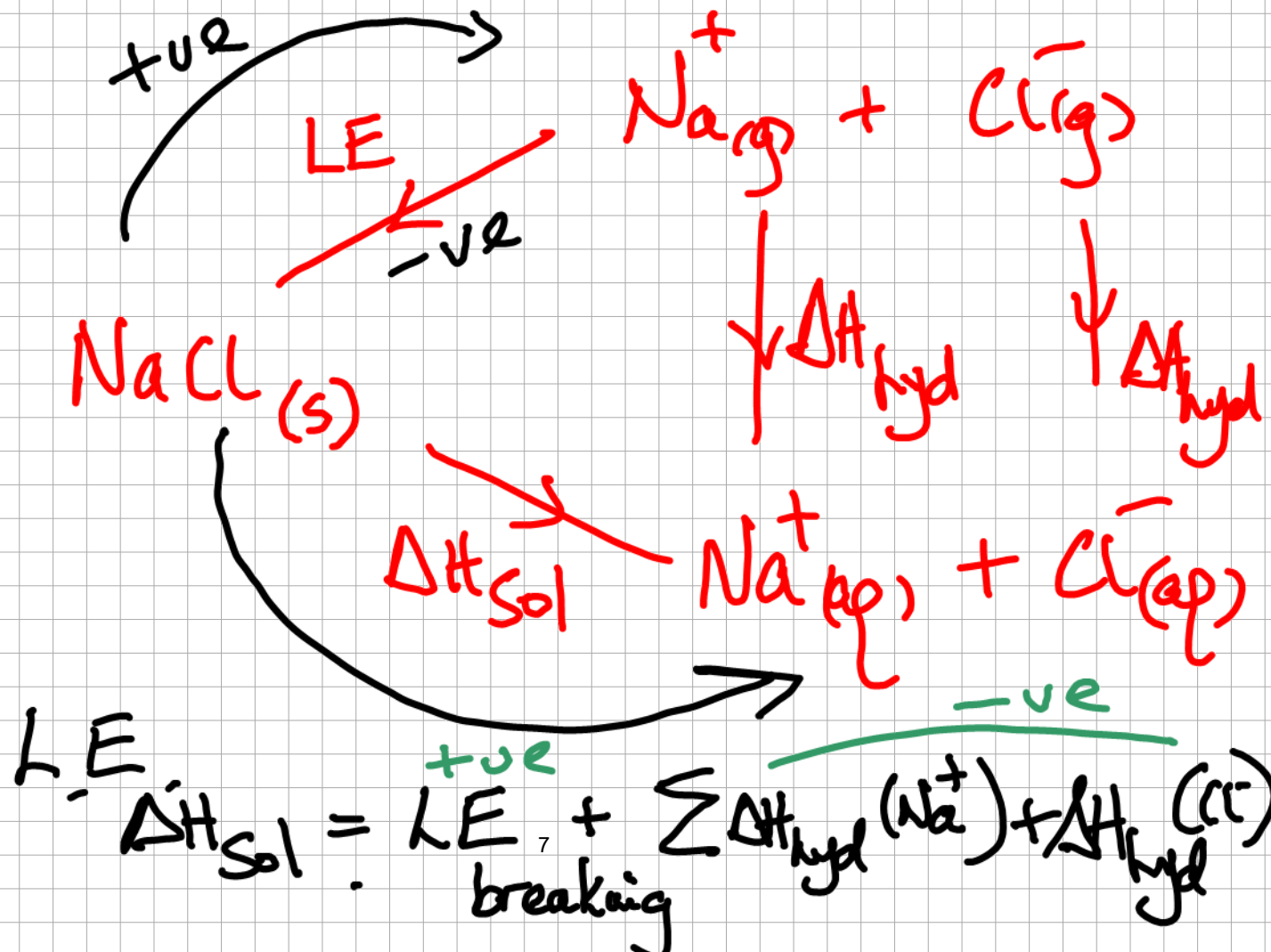
- reacts with hot and concentrated sodium hydroxide solution to form sodium chloride and sodium chlorate(V)

$$\underset{0}{3Cl_2(aq)} + 6NaOH(aq) \longrightarrow \underset{-1}{5NaCl(aq)} + \underset{+5}{NaClO_3(aq)} + 3H_2O(l)$$

hot, concentrated

$+5e^-$ $\quad -5e^-$

Disproportionation



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CHEMISTRY – CH5

P.M. MONDAY, 15 June 2015

1 hour 45 minutes

3 **Boron nitride**

Boron nitride has a giant covalent structure that has the same number of electrons as graphite and diamond. They are said to be isoelectronic. Boron nitride exists in two forms:

- Hexagonal boron nitride has a structure similar to graphite, and is sometimes called 'white graphite' because of its excellent lubricating properties. Unlike graphite, hexagonal boron nitride is an insulator and has applications which depend upon this property.
- Cubic boron nitride has a diamond structure, and is the second hardest natural material known. It has high thermal conductivity and is chemically inert.

(f) Hexagonal boron nitride and graphite have similar structures *(lines 24-26)*. Describe the differences between these two isoelectronic materials in terms of their bonding and structure. [3]

QWC [1]

(f) Any 3 from 4 points for (1) each

All atoms the same in graphite / BN alternate in boron nitride (1)
Atoms in layer of BN lie above each other but are not in graphite (1)
B—N bonds are polarised (or indicated dipole) but graphite is non-polar (1)
p-electrons in BN are localised but in graphite are delocalised (1) [3]

QWC *Organisation of information clearly and coherently; use of specialist vocabulary where appropriate* [1]

4. The leaves of the rhubarb plant are rich in ethanedioic acid (oxalic acid) which is a poisonous compound. A solution containing ethanedioate ions can be formed by boiling rhubarb leaves with water. It can be separated and samples titrated against acidified potassium manganate(VII) to find the concentration of the ethanedioate solution.

(f) Heating ethanedioic acid in glycerol produces methanoic acid, HCOOH.

(iii) A mixture of methanoic acid and sodium methanoate can be used as a buffer solution. State what is meant by a *buffer solution* and explain how a mixture of methanoic acid and sodium methanoate acts as a buffer. [3]

QWC [1]

$HCOOH \rightleftharpoons HCOO^- + H^+$

$HCOONa \rightarrow HCOO^- + Na^+$

ACID (H^+)

$HCOO^- + H^+ = HCOOH$

ALKALI (OH^-)

$HCOOH + OH^- = HCOO^- + H_2O$

(iii) A buffer keeps the pH almost constant when **small amounts** of acid or base are added (1)

$HCOOH \rightleftharpoons HCOO^- + H^+$ (1)

Adding acid shifts the equilibrium to the left which removes H^+ /
Adding base removes H^+ shifts equilibrium to right which replaces H^+ (1)
OR answer in terms of H^+ reacting with methanoate from
sodium methanoate when acid added (1) and methanoic acid replacing H^+
when base removes H^+ (1)

MAX 3 [3]

QWC *Selection of a form and style of writing appropriate to purpose and to complexity of subject matter* [1]

5 *(c)* Bromine reacts with aqueous potassium iodide as shown above, however bromine does not react with aqueous sodium chloride. Use the standard electrode potentials below to explain these observations. [3]

QWC [1]

Half-equation	E^{θ}/V
$I_2 + 2e^- \rightleftharpoons 2I^-$	+0.54
$Br_2 + 2e^- \rightleftharpoons 2Br^-$	+1.09
$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.36

(c) Bromine has a more positive E^{θ} than iodine so it is a stronger oxidising agent (1)

Bromine is able to oxidise iodide (1)

Bromine has a less positive E^{θ} than chlorine so it is a weaker oxidising agent (1)

Bromine is not able to oxidise chloride (1)

MAX 3

OR Calculate EMF for each reaction (1 each) and state that positive EMF means reaction is feasible (1) [3]

QWC *Legibility of text, accuracy of spelling, punctuation and grammar, clarity of meaning* [1]

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CHEMISTRY – CH5

A.M. WEDNESDAY, 22 June 2016

1 hour 45 minutes

3 *(e)* Cars have been developed that run on hydrogen using fuel cells *(lines 23-24)*. Explain the principles underlying the operation of the hydrogen fuel cell. [3]

QWC [1]

.....

.....

(e) The fuel cell uses electrochemical methods to get energy from hydrogen / generates EMF / creates a flow of electricity (1)

Hydrogen is oxidised producing H^+ ions and electrons at anode (1)

(Accept equation)

Oxygen is reduced at the cathode to water (1)

(Accept equation) [3]

QWC *Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning* [1]

4 *(b)* Copper compounds take part in several different types of reaction including ligand substitution and precipitation. Using copper compounds, give an example for both types of reaction, stating any observations. Give the formula for the copper-containing product for each example. [6]

QWC [1]

(b) Suitable example of ligand substitution (1)
e.g. reaction of excess ammonia solution with $CuSO_4/[Cu(H_2O)_6]^{2+}$

Suitable observation (1)
e.g. formation of royal blue solution

Correct formula (1)
e.g. $[Cu(NH_3)_4(H_2O)_2]^{2+}$

Suitable example of precipitation (1)
e.g. reaction between $CuSO_4$ and NaOH

Suitable observation (1)
e.g. pale blue precipitate

Correct formula (1)
e.g. $Cu(OH)_2$ [6]

QWC *The information is organised clearly and coherently, using specialist vocabulary where appropriate* [1]

5. *(a)* Group II elements can only show an oxidation state of II, however Group IV elements can show oxidation states of II and IV in their compounds.

(i) State how the relative stability of these oxidation states changes as Group IV is descended and give a reason for this trend. [2]

(ii) The characteristics of the Group IV elements and their compounds change significantly from carbon to lead. Show how this statement is true by comparing:

- the reactions, if any, of carbon dioxide and lead(II) oxide with acids and alkalis
- the reduction-oxidation properties of carbon monoxide and lead(IV) oxide.

Your answer should include any relevant chemical equations. [6]

QWC [1]

(a) (i) Oxidation state II becomes more stable / oxidation state IV becomes more unstable (1)

Inert pair effect / the two outer s electrons become more stable (as group is descended) (1) [2]

(ii) Carbon dioxide is acidic while lead(II) oxide is amphoteric (1)

e.g. $CO_2 + 2NaOH \rightarrow Na_2CO_3 + H_2O$ (1)

$Pb^{2+} + 2OH^- \rightarrow Pb(OH)_2$

$Pb(OH)_2 + 2OH^- \rightarrow [Pb(OH)_4]^{2-}$ (1)

or

$PbO + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O$

$PbO + 2OH^- + H_2O \rightarrow [Pb(OH)_4]^{2-}$ (1)

Carbon monoxide is a reducing agent while lead(IV) is an oxidizing agent (1)

e.g. $CO + CuO \rightarrow CO_2 + Cu$ (1)

$PbO_2 + 4HCl \rightarrow PbCl_2 + Cl_2 + 2H_2O$ (1) [6]

QWC *Selection of a form and style of writing appropriate to purpose and to complexity of subject matter* [1]