Shapes of Molecules and Ions

A Level

Part A F_2O

By considering the number of lone and bonding pairs of electrons, predict the shape of F_2O.

Part B H_3O^+

By considering the number of lone and bonding pairs of electrons, predict the shape of H_3O^+.

Part C ClF_4^-

By considering the number of lone and bonding pairs of electrons, predict the shape of ClF_4^-.

Part D SbF_5^{n-}

Antimony, Sb, is in group 15 of the Periodic Table. It forms a series of salts which contain the SbF_5^{n-} anion, the structure of which is a square-based pyramid:

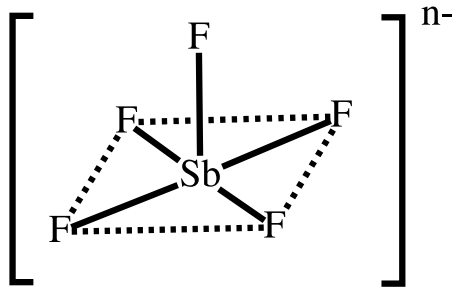

Figure 1: Structure of the SbF_5^{n-} anion

Deduce the total number of electrons around the antimony atom.

Deduce the value of n.

Adapted with permission from UCLES, A-Level Chemistry, June 1991, Paper 3, Question 2

Shapes of Xenon Compounds

A Level

C C C

For each of the following, deduce the shape of the molecules and enter a one to two word answer, using appropriate shape of molecule terminology, e.g. "linear".

Part A XeF_2

Describe the shape of XeF_2.

Part B $XeOF_2$

Describe the shape of $XeOF_2$.

Part C XeO_4

Describe the shape of XeO_4.

Part D XeF_4

Describe the shape of XeF_4.

Part E $\mathrm{XeOF_4}$

Describe the shape of $\mathrm{XeOF_4}$.

Part A adapted with permission from OCR, STEP Chemistry, June 1999, Question 5

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Ferrite

A Level

Aerials in portable radios are made of a mixed oxide of calcium and iron known as 'Ferrite'. It contains 18.5 % calcium and 51.9 % iron by mass. Calculate the empirical formula of 'Ferrite' and hence deduce the oxidation number of the iron it contains.

Part A Empirical formula

Empirical Formula:

Part B Oxidation number

Oxidation number:

Adapted with permission from UCLES, A-Level Chemistry, June 1992, Paper 2, Question 3

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Oxides of Nitrogen

A Level

C C C

Part A Oxides of nitrogen

In an attempt to establish the formula of an oxide of nitrogen, a known volume of the pure gas was mixed with hydrogen and passed over a catalyst at a suitable temperature. 100% conversion of the oxide to ammonia and water was shown to have taken place.

$$\mathrm{N}_x\mathrm{O}_y \xrightarrow[\text{catalyst}]{\mathrm{H}_2} x\,\mathrm{NH_3} + y\,\mathrm{H_2O}$$

$2400\,\mathrm{cm}^3$ of the nitrogen oxide, measured at room temperature and pressure (RTP) produced $7.200\,\mathrm{g}$ of water. The ammonia produced was neutralised by $200\,\mathrm{cm}^3$ of $1.0\,\mathrm{mol\ dm}^{-3}$ HCl.

[Molar volume of gas at RTP = $24000\,\mathrm{cm}^3\ \mathrm{mol}^{-1}$]

What was the oxidation number of nitrogen in the solid oxide?

- +1
- +2
- +3
- +4
- +5

Part B Oxidation numbers of nitrogen

The key stage in the manufacture of nitric acid is the reaction of ammonia with air in the presence of a platinum-rhodium gauze:

$$4\,NH_3\,(g) + 5\,O_2\,(g) \longrightarrow 4\,NO\,(g) + 6\,H_2O\,(g)$$

What is the oxidation number of nitrogen in

NH_3

NO

Part A adapted with permission from UCLES, A-Level Chemistry, November 1989, Paper 3, Question 2;
Part B adapted with permission from UCLES, A-Level Chemistry, November 1995, Paper 3, Question 1

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Essential Pre-Uni Chemistry K3.3

A Level

Complete the balanced equations to show the reactions between the following pairs of substances in alkaline aqueous conditions (no fractions).

Part A Sulfite and bromate(V)

sulfite and bromate(V)

$$3\,SO_3^{2-}(aq) + \ ?BrO_3^{-}(aq) \longrightarrow 3\,SO_4^{2-}(aq) + \ ?$$

Part B Hydrogen peroxide and chromium(III)

hydrogen peroxide and chromium(III)

$$3\,H_2O_2(aq) \ + \ ?Cr^{3+}(aq) \ + \ ?OH^{-}(aq) \longrightarrow \ ?CrO_4^{2-}(aq) \ + \ ?$$

Part C Chlorate(I) and iron(III)

chlorate(I) and iron(III)

$$?ClO^{-}(aq) \ + \ ?Fe(OH)_3(s) \longrightarrow \ ?FeO_4^{2-}(aq) \ + \ ?Cl_2(g) + \ ? \ + \ ?$$

Part D Manganate(VI) and methanoate

manganate(VI) and methanoate

$$?\mathrm{HCOO^-\,(aq)} + \mathrm{MnO_4{}^{2-}\,(aq)} \longrightarrow \mathrm{MnO_2\,(s)} + \mathrm{OH^-\,(aq)} + \ ?$$

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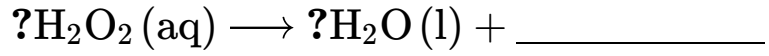
STEM SMART Chemistry Week 16

Essential Pre-Uni Chemistry K4.2

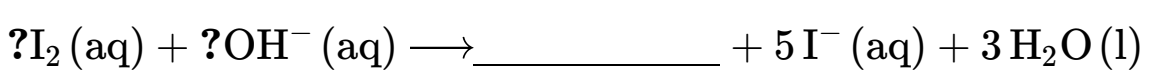
A Level

Complete and balance the following equations that represent disproportionation reactions.

Part A **(a)**

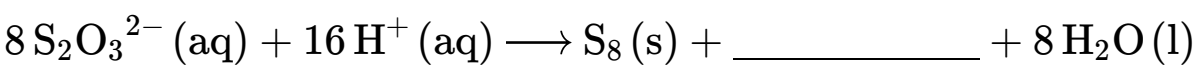


Part B **(b)**



Please **click on and drag** the pre-loaded species in the equation editor to create your chemical equation.

Part C **(c)**



Please **click on and drag** the pre-loaded species in the equation editor to create your chemical equation.

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Iron in a Nail

A Level

A nail of mass $1.40\,\mathrm{g}$ was dissolved in an excess of dilute sulfuric acid to form $100\,\mathrm{cm}^3$ of solution. A $10\,\mathrm{cm}^3$ sample of this solution required $4.0 \times 10^{-4}\,\mathrm{mol}$ of manganate (VII) for complete oxidation.

In acidic solution:

$$\mathrm{MnO_4^-} + 8\,\mathrm{H^+} + 5\,\mathrm{e^-} \longrightarrow \mathrm{Mn^{2+}} + 4\,\mathrm{H_2O}$$

By assuming that, in dissolving in sulfuric acid, the iron in the nail was converted entirely into $\mathrm{Fe^{2+}(aq)}$ and that manganate (VII) oxidises $\mathrm{Fe^{2+}}$ to $\mathrm{Fe^{3+}}$, calculate:

Part A Moles of $\mathrm{Fe^{2+}}$

The number of moles of $\mathrm{Fe^{2+}}$ produced from the nail.

Part B % of Fe

The percentage of iron in the nail.

Adapted with permission from UCLES, A-Level Chemistry, June 1992, Paper 3, Question 2

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Essential Pre-Uni Chemistry D3.1

A Level

There are trends evident in atomic and ionic radii. Ionisation energies also show trends. Complete the sentences below with the words 'increase' or 'decrease', to indicate what happens to the radii and ionisation energy of the atoms or ions [(a)–(f)], or to the ionisation energies [(g)–(i)].

Part A Along a period, L-R

Going along a period from left to right, the atomic radii...

- decrease
- increase

Part B Down a group

Going down a group, the atomic radii...

- increase
- decrease

Part C Electrons removed

As successive electrons are removed from the same atom/ion, the radii...

- increase
- decrease

Part D Same charge, down a group

The radii of ions of the same charge, on descending a group...

- decrease
- increase

Part E Adding electrons

As successive electrons are added to one atom to make increasingly negative ions, the radii...

- increase
- decrease

Part F Along period, L-R

Along a period from left to right, the radii of isoelectronic species generally...

- increase
- decrease

Part G Along period, L-R

Along a period from left to right, the first ionisation energies generally...

- ○ decrease
- ○ increase

Part H Down a group

Going down a group, the first ionisation energies...

- ○ decrease
- ○ increase

Part I Ionisation energies

Successive ionisation energies for the same element...

- ○ increase
- ○ decrease

Gameboard:

STEM SMART Chemistry Week 16

High oxidation states

A Level

The maximum possible oxidation state of an element could occur if all the outermost electrons, the so-called valence electrons, were used in bonding. The maximum number of valence electrons is equal to the group number for Groups 1 to 11, and the group number minus 10 for elements from Groups 12 to 18. Note the maximum possible oxidation state is not always achievable; however, each of the following elements forms an oxide exhibiting the theoretical maximum oxidation state for that element. Give the formula for each oxide.

Part A **Xenon** (Xe)

Part B **Polonium** (Po)

Part C **Chlorine** (Cl)

Part D **Niobium** (Nb)

Part E **Osmium** (Os)

Part F **Yttrium** (Y)

Adapted with permission from the Cambridge Chemistry Challenge 2021, Question 2

Gameboard:

STEM SMART Chemistry Week 16

LiH and PCl_3

A Level

C C C

Reaction of $7.9\,\text{g}$ of LiH with $45.8\,\text{g}$ of PCl_3 produces $42.4\,\text{g}$ of a white solid **A** and $8.0\,\text{dm}^3$ of a colourless gas **B** (at RTP). Compound **B** ($8.0\,\text{dm}^3$) spontaneously ignites in air to give $32.7\,\text{g}$ of a single compound **C**. A solution of **C** ($9.8\,\text{g}$ dissolved in $100\,\text{cm}^3$) is neutralised by $150\,\text{cm}^3$ of $2.0\,\text{mol dm}^{-3}$ $NaOH$ solution.

Part A A

Deduce the formula of compound **A**.

Part B B

Deduce the formula of compound **B**.

Part C C

Deduce the formula of compound **C**.

Part D Acid

Based on the number of acidic protons in **C**, what term would you use to describe this acid?