14–16 years
Stretch and challenge

Ionic bonding and electron transfer

ROYAL SOCIETY OF CHEMISTRY

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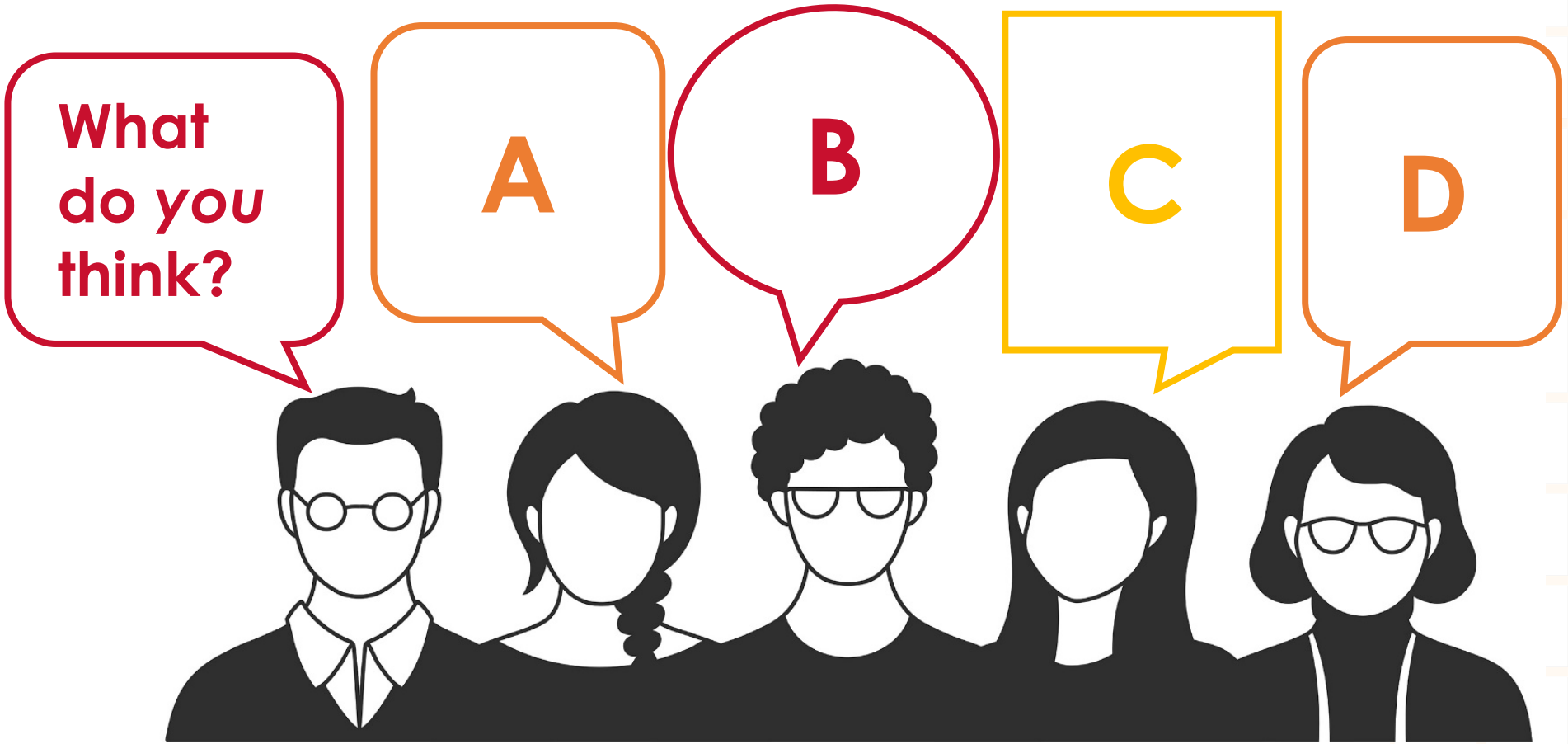
https://rsc.li/4jUWg02

Introduction

Read through ‘The problem’ and then the four opinions A, B, C and D.

Decide in your group whether you agree with all, or any of each of the opinions and then what your own response to the information is.



The problem

We sometimes explain the formation of ions in terms of atoms transferring electrons in order to gain a full outer shell of electrons (noble gas electron configurations).

But for the process:

$$\mathbf{Mg(g) + O(g) \rightarrow Mg^{2+}(g) + O^{2-}(g)}$$

$$\mathbf{\Delta H = \ +2846\ kJ\ mol^{-1}}$$

The process is extremely **endothermic**!

It requires a large investment of energy to transfer the electrons from Mg to O.

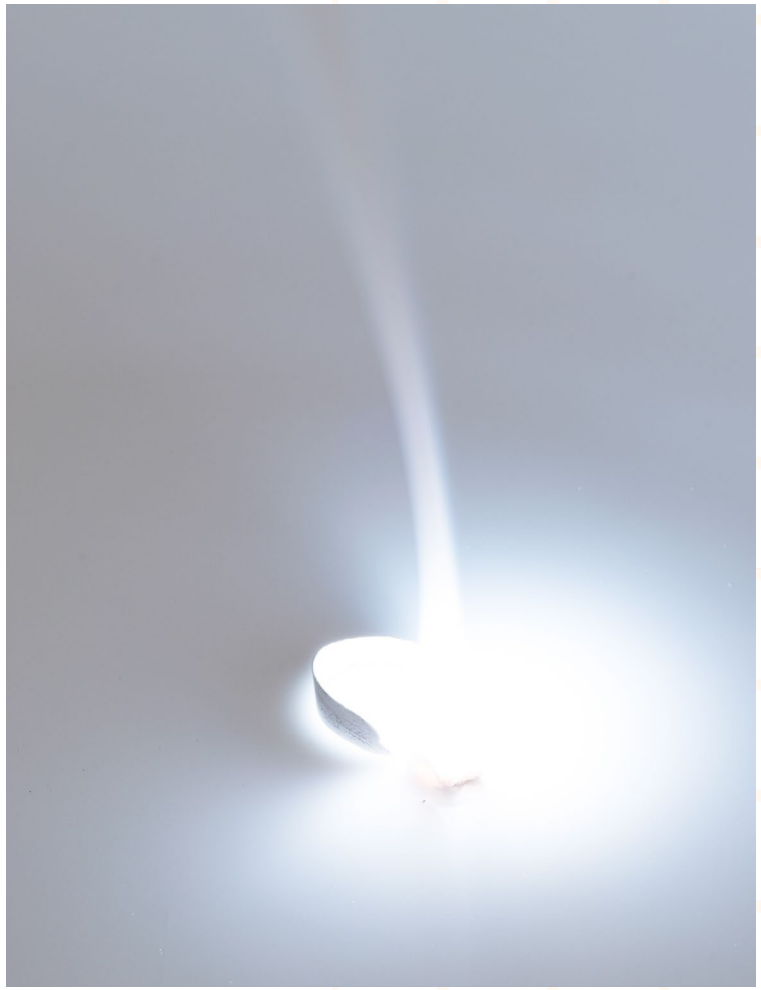


Image source: © Shutterstock / usk75

Magnesium burns with a bright white light

Group discussion

Opinions

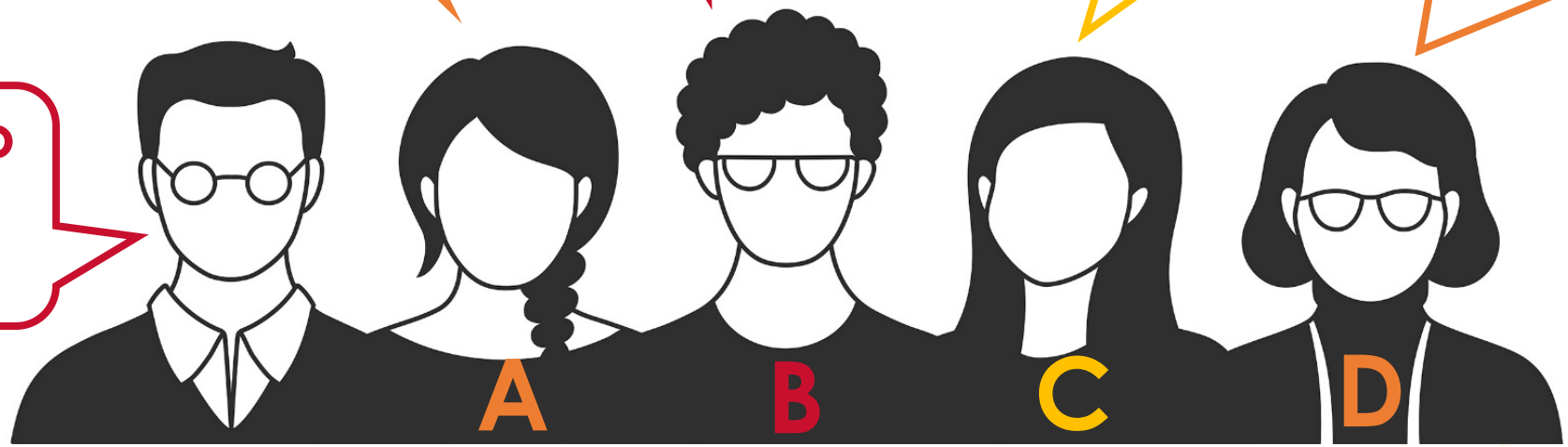
A We know by experience that magnesium burns exothermically so electron transfer cannot be the only thing going on.

B The bonding in magnesium oxide must not be ionic – it must be covalent.

C Ionic bonding occurs because oppositely charged ions attract each other. Energy is given out when the ions come together in a lattice.

D When you react magnesium and oxygen you do not actually have separate atoms. The magnesium is in a giant lattice and the oxygen is in O_2 molecules.

What do *you* think?



Discussion of answers

Opinion	Discussion
A	Person A is making a sensible point. The information given suggests that the process of electron transfer on its own is strongly endothermic. Since burning magnesium is exothermic, it must involve more than electron transfer.
B	Person B has abandoned the ionic model too readily. There is good evidence for the existence of ions – e.g. the conductivity of solutions and molten salts. Since magnesium is a metal and oxygen a non-metal, the bonding is ionic.
C	Person C has made a crucial point. The exothermic part of the whole process comes from the coming together of oppositely charged ions into a giant lattice. Opposite charges have potential energy when they are held apart which is converted to heat when they move closer. The mutual attraction of oppositely charged ions is the driving force behind ionic bonding.
D	Person D is correct that the data are about isolated atoms, but the real reaction is between solid magnesium and oxygen molecules. However, this observation only gets us so far. You can form the isolated atoms of magnesium and oxygen from the solid and gas by investing the energy to break all the bonds. Breaking the bonds will be endothermic, so we have not explained why the process of burning is exothermic and indeed what drives the magnesium to react with the oxygen.

A model of ionic bonding

A model of an ionic lattice; the ions are held to each other by electrostatic attraction.