InkChemistry

ANSWER BOOK

Electronegativity, polarity and intermolecular forces

Bonding and structure · Unit C03

AQA 3.1.3.6, 3.1.3.7 · OCR A 2.2.2

19 questions · 58 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 EPI-Q9

B1 NH_3 and HF form hydrogen bonds, as each has H bonded to N or F and a lone pair on that atom. **B1** CH_4 and HCl do not, because carbon and chlorine are not electronegative enough. [2]

A2 EPI-Q20

B1 grease and hexane are both non-polar, so the induced dipole–dipole forces they form with each other are like those broken in each, and the grease dissolves. **B1** grease can form only induced dipole–dipole forces with water, which cannot make up for the hydrogen bonds between water molecules that would have to break. [2]

A3 EPI-Q1

B1 the power of an atom to attract the pair of electrons in a covalent bond towards itself. [1]

SECTION B · Standard, 3 to 5 marks

B1 EPI-Q2

B1 across the period the nuclear charge increases. **B1** the bonding electrons stay in the same shell with similar shielding, so they are attracted more strongly. **B1** down the group the atoms have more shells, so the bonding pair is further from the nucleus. **B1** and is more shielded by inner electrons, so it is attracted less strongly despite the greater nuclear charge. [4]

B2 EPI-Q4

B1 the electrons in a Br_2 molecule are constantly moving, so at an instant they can be unevenly distributed. **B1** this gives the molecule an instantaneous dipole. **B1** the instantaneous dipole induces a dipole in a neighbouring molecule by attracting or repelling its electrons. **B1** the δ+ end of one dipole attracts the δ- end of the other, so the molecules attract. [4]

B3 EPI-Q6

B1 oxygen is much more electronegative than sulfur, so the O–H bond is very polar and the hydrogen is strongly δ+. **B1** water molecules form hydrogen bonds between a δ+ hydrogen and a lone pair on the oxygen of another molecule. **B1** H_2S molecules cannot form hydrogen bonds, only weaker permanent dipole–dipole and induced dipole–dipole forces. **B1** more energy is needed to overcome the hydrogen bonds between water molecules. [4]

B4 EPI-Q8

B1 partial charges shown: δ- on each oxygen and δ+ on each hydrogen. **B1** at least one lone pair shown on the oxygen that accepts the hydrogen bond. **B1** the hydrogen bond drawn as a dashed line from a δ+ hydrogen of one molecule to the lone pair on the oxygen of the other. **B1** the O–H···O atoms in a straight line, at 180°. [4]

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B5 EPI-Q14 — [4]

B1 both have similar induced dipole–dipole forces, since they have the same number of electrons. **B1** butan-1-ol has an O–H group, so its molecules form hydrogen bonds to each other. **B1** pentane is non-polar and has only induced dipole–dipole forces. **B1** the hydrogen bonds need extra energy to overcome, so butan-1-ol boils about 80 °C higher.

B6 EPI-Q3 — [3]

B1 chlorine is more electronegative than carbon, so each C–Cl bond is polar, Cδ+–Clδ-. **B1** the molecule is tetrahedral and symmetrical. **B1** the four bond dipoles point in directions that cancel, so there is no overall dipole.

B7 EPI-Q5 — [3]

B1 the molecules have more electrons down the group. **B1** so the induced dipole–dipole forces between the molecules are stronger. **B1** more energy is needed to overcome these forces, so the boiling point is higher.

B8 EPI-Q7 — [3]

B1 the two isomers have the same number of electrons. **B1** pentane is a straight chain, and its molecules touch each other over a larger area than the nearly spherical 2,2-dimethylpropane molecules. **B1** so the induced dipole–dipole forces between pentane molecules are stronger and need more energy to overcome.

B9 EPI-Q10 — [3]

B1 Br_2 has only induced dipole–dipole forces between its molecules. **B1** HCl has permanent dipole–dipole forces as its strongest force. **B1** CH_3OH forms hydrogen bonds through its O–H group.

B10 EPI-Q11 — [3]

B1 trichloromethane is a polar molecule. **B1** the C–Cl bonds are polar and the C–H bond is almost non-polar. **B1** so the tetrahedral molecule is not symmetrical in charge, and the bond dipoles do not cancel.

B11 EPI-Q12 — [3]

B1 the induced dipole–dipole forces are similar, since both molecules have 18 electrons. **B1** hydrazine has H atoms bonded to N and lone pairs on N, so its molecules form hydrogen bonds; ethane cannot. **B1** the hydrogen bonds need much more energy to overcome, so hydrazine boils far higher.

B12 EPI-Q13 — [3]

B1 propanone has no hydrogen bonded to oxygen, so it cannot hydrogen bond to itself. **B1** its oxygen has lone pairs and is δ-. **B1** δ+ hydrogen atoms of water molecules form hydrogen bonds to those lone pairs, so propanone and water attract each other.

B13 EPI-Q15 — [3]

B1 the claim is wrong: no O–H bonds are broken when water boils, and the vapour is still H_2O molecules. **B1** boiling overcomes the forces between molecules, which in water are hydrogen bonds. **B1** the high boiling point is due to hydrogen bonding between water molecules, about two per molecule, not to the strength of the covalent bonds.

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B14 EPI-Q16

B1 each water molecule has two δ+ hydrogen atoms and two lone pairs. **B1** so it can form on average two hydrogen bonds; HF has only one hydrogen per molecule and averages one. **B1** more hydrogen bonds per molecule in water need more energy to overcome. [3]

B15 EPI-Q18

B1 a molecule in the body of a liquid is attracted equally in every direction, but a molecule at the surface has neighbours only beside and below it, so it is pulled inwards. **B1** in water the inward pull comes from hydrogen bonds; in hexane only from induced dipole–dipole forces. **B1** hydrogen bonds are stronger, so more energy is needed to enlarge the surface of water, and its surface tension is higher. [3]

B16 EPI-Q19

B1 1-chlorobutane has no hydrogen bonded to N, O or F, so it cannot form hydrogen bonds with water. **B1** it can form only permanent dipole–dipole and induced dipole–dipole forces with water molecules. **B1** these are weaker than the hydrogen bonds between water molecules that would have to be broken, so it does not dissolve. [3]

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