Exercise walk-through

Intramolecular Force and Potential Energy ▪ 2.2

eXercise

You must be able to

- read a **potential-energy vs distance 势能-距离** curve for two atoms
- identify the **bond length 键长** (minimum) and **bond energy 键能** (well depth)
- link stronger bonds to deeper, narrower wells

Method — The potential-energy curve

As two atoms approach, attraction lowers the energy until repulsion of the nuclei takes over. The curve has a **minimum**: that distance is the **bond length**, and the depth of the well below zero is the **bond energy** (energy to separate the atoms).

Method — Reading the curve

- The x-position of the minimum = bond length.
- The depth of the minimum = bond energy (how strongly bonded).
- To the left of the minimum, energy rises steeply — nuclei repel.

Method — Comparing bonds

A **stronger** bond has a **deeper** well (larger bond energy) and usually a **shorter** bond length. A triple bond is deeper and shorter than a double, which is deeper and shorter than a single.

Method — Coulomb's law link

Bond strength grows with the product of the charges and shrinks with distance ($E \propto \frac{q_1 q_2}{r}$). Smaller, more highly charged ions bond more strongly.

Practice 2.1 ▪ 1 mark

On a potential-energy curve, what does the position of the minimum represent?

Solution 2.1

Worked steps

The bond length (the equilibrium separation of the atoms) B1.

Practice 2.2 ▪ 1 mark

What does the depth of the well represent?

Solution 2.2

Method: The potential-energy curve

Worked steps

The bond energy — the energy needed to break the bond B1.

Practice 2.3 ▪ 1 mark

Two bonds A and B have well depths 400 and 250 kJ/mol. Which is stronger?

Solution 2.3

Method: Comparing bonds

Worked steps

A (deeper well, 400 kJ/mol) B1.

Exam-style 3.1 ▪ 1 mark

On a potential-energy vs distance curve, the bond length is the distance where the energy is

A zero

B maximum

C minimum

D infinite

Solution 3.1

Method: The potential-energy curve

A zero

B maximum

C minimum ✓

D infinite

Worked steps

C — the bond length is at the energy minimum.

Exam-style 3.2 ▪ 1 mark

Two diatomic molecules have potential-energy curves. Molecule X has its minimum at 110 pm with depth 500 kJ/mol; molecule Y at 130 pm with depth 300 kJ/mol.

(a) Which has the shorter bond?

(b) Which has the stronger bond?

(c) State the relationship between bond length and bond strength suggested here.

Solution 3.2

Method: The potential-energy curve

Worked steps

(a) X (110 pm) B1. (b) X (500 kJ/mol) B1. (c) Shorter bonds tend to be stronger B1.

Exam-style 3.3 ▪ 2 marks

Using Coulomb's law, explain why the ionic bond in MgO (ions $2+$ and $2-$) is stronger than in NaCl (ions $1+$ and $1-$).

Solution 3.3

Worked steps

Coulomb's law $E \propto \frac{q_1 q_2}{r}$: MgO has charges $2 \times 2 = 4$ vs $1 \times 1 = 1$ for NaCl, so the attraction (and bond strength) is much greater M1 A1.