

## 2.6 Resonance and Formal Charge

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

Total: 10 marks

**KEY WORDS** formal charge 形式电荷 • resonance 共振 • lewis diagram 路易斯结构

### Objective

Build the skills to answer exam questions on **resonance and formal charge**.

**You must be able to:**

- draw **resonance** 共振 structures when more than one valid Lewis diagram exists
- calculate **formal charge** 形式电荷 = (valence  $e^-$ ) – (lone  $e^-$ ) –  $\frac{1}{2}$ (bonding  $e^-$ )
- use formal charge to choose the best structure

### 1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

#### ■ Resonance

When electrons could be placed in more than one equally valid way, the molecule is a **blend** (resonance hybrid) of those structures. In  $O_3$  (ozone) the double bond is shared between both O–O positions, so both bonds are identical.

#### ■ Formal charge

For each atom,

$$FC = (\text{valence } e^-) - (\text{nonbonding } e^-) - \frac{1}{2}(\text{bonding } e^-).$$

#### ■ A worked formal charge

In  $CO_2$ , the carbon: valence 4, lone 0, bonding 8 (two double bonds):  $FC = 4 - 0 - 4 = 0$ . Each oxygen:  $6 - 4 - 2 = 0$ . All zero — a good structure.

#### ■ Choosing the best structure

The **best** Lewis structure has formal charges **closest to zero**, and any negative formal charge on the **most electronegative** atom. Use this to pick between candidates.

## 2 Practice

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Now apply the methods above.

**2.1** Write the formula for formal charge. [1]

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**2.2** Find the formal charge on N in  $\text{NH}_4^+$  (valence 5, 0 lone electrons, 8 bonding electrons). [2]

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**2.3** What does it mean that ozone  $\text{O}_3$  has resonance structures? [1]

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## 3 Exam-style questions

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**3.1** The preferred Lewis structure has formal charges that are [1]

|   |   |
|---|---|
| A | B |
| C | D |

**A** as large as possible

**B** as close to zero as possible

**C** all positive

**D** all on carbon

**3.2** In one resonance structure of  $\text{NO}_3^-$ , an oxygen has 6 nonbonding electrons and 2 bonding electrons (a single bond).

(a) Find the formal charge on that oxygen. [2]

(b) State what the true structure looks like given resonance. [1]

**3.3** Explain why all three N–O bonds in  $\text{NO}_3^-$  have the same length, using the idea of resonance. [2]