

1.

What is the shape of  $\text{NO}_2^+$ ?

- |                 |                          |
|-----------------|--------------------------|
| <b>A</b> Linear | <b>C</b> Trigonal planar |
| <b>B</b> Bent   | <b>D</b> Tetrahedral     |

2.

Which of the following is polar?

- |                        |                         |                        |                         |
|------------------------|-------------------------|------------------------|-------------------------|
| <b>A</b> $\text{CO}_2$ | <b>B</b> $\text{CCl}_4$ | <b>C</b> $\text{BF}_3$ | <b>D</b> $\text{PCl}_3$ |
|------------------------|-------------------------|------------------------|-------------------------|

3.

Which of the following molecules exhibit(s) hydrogen bonding?

- I**  $\text{NH}_3$     **II**  $\text{CH}_3\text{NH}_2$     **III**  $\text{HF}$     **IV**  $\text{CH}_3\text{F}$

- |                             |                          |
|-----------------------------|--------------------------|
| <b>A</b> I, II and III only | <b>C</b> I and III only  |
| <b>B</b> IV only            | <b>D</b> III and IV only |

4.

In which of the following are the molecules arranged in order of increasing boiling point (lowest first)?

- |                                    |                          |                                 |
|------------------------------------|--------------------------|---------------------------------|
| <b>A</b> $\text{NH}_3$             | $\text{N}_2$             | $\text{Br}_2$                   |
| <b>B</b> $\text{H}_2\text{O}$      | $\text{H}_2\text{S}$     | $\text{H}_2\text{Se}$           |
| <b>C</b> $\text{CH}_3\text{Cl}$    | $\text{CH}_2\text{Cl}_2$ | $\text{CHCl}_3$                 |
| <b>D</b> $\text{C}_4\text{H}_{10}$ | $\text{C}_3\text{H}_8$   | $\text{C}_2\text{H}_5\text{OH}$ |

5.

What is the F–B–F bond angle in  $\text{BF}_4^-$ ?

- |                        |                      |                      |                     |
|------------------------|----------------------|----------------------|---------------------|
| <b>A</b> $109.5^\circ$ | <b>B</b> $107^\circ$ | <b>C</b> $120^\circ$ | <b>D</b> $90^\circ$ |
|------------------------|----------------------|----------------------|---------------------|

6.

Which of the following will be the worst conductor of electricity?

- |                                    |                                    |
|------------------------------------|------------------------------------|
| <b>A</b> $\text{Mg(s)}$            | <b>C</b> $\text{MgCl}_2(\text{l})$ |
| <b>B</b> $\text{SiCl}_4(\text{l})$ | <b>D</b> $\text{C(graphite,s)}$    |

7.

When the compounds  $\text{C}_2\text{H}_6$ ,  $\text{C}_2\text{H}_4$ ,  $\text{C}_2\text{H}_2$  and  $\text{C}_6\text{H}_6$  are arranged in order of increasing C–C bond lengths (shortest first) the correct order is:

- |                                 |                        |                        |                        |
|---------------------------------|------------------------|------------------------|------------------------|
| <b>A</b> $\text{C}_2\text{H}_6$ | $\text{C}_2\text{H}_4$ | $\text{C}_2\text{H}_2$ | $\text{C}_6\text{H}_6$ |
| <b>B</b> $\text{C}_6\text{H}_6$ | $\text{C}_2\text{H}_4$ | $\text{C}_2\text{H}_2$ | $\text{C}_2\text{H}_6$ |
| <b>C</b> $\text{C}_2\text{H}_2$ | $\text{C}_6\text{H}_6$ | $\text{C}_2\text{H}_4$ | $\text{C}_2\text{H}_6$ |
| <b>D</b> $\text{C}_2\text{H}_2$ | $\text{C}_2\text{H}_4$ | $\text{C}_6\text{H}_6$ | $\text{C}_2\text{H}_6$ |

8.

Ammonia,  $\text{NH}_3$ , reacts with hydrogen ions,  $\text{H}^+$ , to form ammonium ions,  $\text{NH}_4^+$ .

- (a) Draw a Lewis (electron dot) structure of ammonia and state its shape and bond angle. (3)
- (b) Predict and explain whether the ammonia molecule is polar. (2)
- (c) Draw a Lewis (electron dot) structure of the ammonium ion and state its shape and bond angle. (3)
- (d) State the name of the bond that forms between ammonia and the hydrogen ion, and explain its formation. (2)
- (e) Explain why the bond angle in ammonia is different from the bond angle in the ammonium ion. (3)

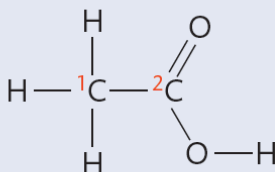
9.

VSEPR theory can be used to predict the shapes of molecules.

- (a) Explain the application of VSEPR theory in the following, including in your answers full Lewis (electron dot) structures, the name of the shape of the molecule and bond angles present.
  - (i)  $\text{PH}_3$
  - (ii)  $\text{H}_2\text{O}$
  - (iii)  $\text{C}_2\text{H}_6$
  - (iv)  $\text{CH}_3\text{CHO}$  (12)
- (b) Only one of the molecules in (a) is able to form intermolecular hydrogen bonding. State which molecule this is, and describe the features it possesses which make it possible for it to form hydrogen bonds. (2)

10.

The structure of ethanoic acid is shown below.



- (a) Comment on whether or not this representation is a Lewis (electron dot) structure. (3)
- (b) Predict the bond angles around each of the two carbon atoms labelled 1 and 2  
C1 bond angle: \_\_\_\_\_ C2 bond angle: \_\_\_\_\_ (2)
- (c) Compare and contrast the bonds between the carbon atom and the two oxygen atoms in the molecule. (2)
- (d) When ethanoic acid ionizes it loses a hydrogen ion and forms the ethanoate ion  $\text{CH}_3\text{COO}^-$ .

Explain why in this structure, the carbon-oxygen bonds are different from either of the carbon-oxygen bonds in ethanoic acid. (3)