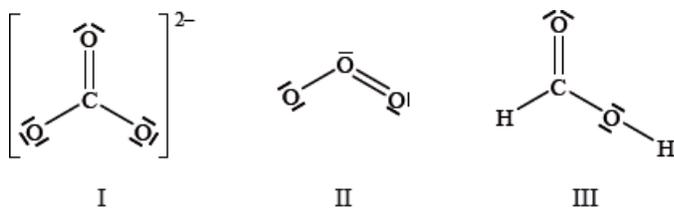


## 14.1B Expanded Octet, Resonance and Molecular Shapes

### Past Exam Questions (Paper 1, 2)

1. [1 mark]

Which species have delocalized electrons?



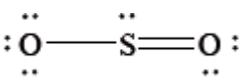
- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

2. [1 mark]

Which species does **not** contain delocalized electrons?

- A.  $\text{CH}_3\text{CH}_2\text{O}^-$
- B.  $\text{CH}_3\text{CO}_2^-$
- C.  $\text{O}_3$
- D.  $\text{NO}_3^-$

3. [1 mark]

The Lewis structure of  $\text{SO}_2$  is given below. 

What is the shape of the  $\text{SO}_2$  molecule?

- A. Bent (V-shaped)
- B. Linear
- C. T-shaped
- D. Triangular planar

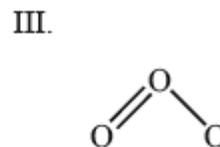
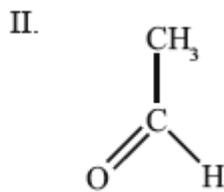
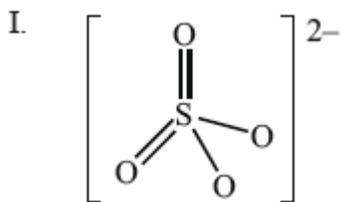
4. [1 mark]

Which species does **not** have delocalized electrons?

- A.  $\text{NO}_3^-$
- B.  $\text{NO}_2^-$
- C.  $\text{O}_3$
- D.  $\text{C}_3\text{H}_6$

5. [1 mark]

Which species contain delocalized electrons?



- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

6. [1 mark]

Which molecule is trigonal bipyramidal in shape?

- A.  $\text{PCl}_3$
- B.  $\text{SiCl}_4$
- C.  $\text{PCl}_5$
- D.  $\text{SF}_6$

7. [1 mark]

What is correct for  $\text{PCl}_5$  ?

	Shape	Bond angle(s)
A.	Octahedral	$90^\circ$ and $180^\circ$
B.	Trigonal pyramidal	$107^\circ$
C.	Square pyramidal	$90^\circ$ and $180^\circ$
D.	Trigonal bipyramidal	$90^\circ$ , $120^\circ$ and $180^\circ$

8. [1 mark]

Which combination of shape and bond angle is correct for a molecule of xenon tetrafluoride,  $\text{XeF}_4$  ?

	Shape	Bond angle
A.	square pyramid	$90^\circ$
B.	square planar	$90^\circ$
C.	tetrahedral	$109.5^\circ$
D.	octahedral	$90^\circ$

9. [1 mark]

Which species breaks the octet rule?

- A.  $\text{PCl}_3$
- B.  $\text{BF}_4^-$
- C.  $\text{SCl}_4$
- D.  $\text{NH}_4^+$

10. [1 mark]

In which group do both compounds contain delocalized electrons?

- A.  $\text{C}_6\text{H}_{10}$ ,  $\text{C}_5\text{H}_{10}$
- B.  $\text{Na}_2\text{CO}_3$ ,  $\text{NaOH}$
- C.  $\text{NaHCO}_3$ ,  $\text{C}_6\text{H}_6$
- D.  $\text{NaHCO}_3$ ,  $\text{C}_6\text{H}_{12}$

11. [1 mark]

Which species has bond angles of  $90^\circ$ ?

- A.  $\text{AlCl}_4^-$
- B.  $\text{ICl}_4^-$
- C.  $\text{NH}_4^+$
- D.  $\text{SiCl}_4$

12. [1 mark]

Which species have resonance structures?

- I. Ozone,  $O_3$
  - II. Carbon dioxide,  $CO_2$
  - III. Benzene,  $C_6H_6$
- A. I and II only
  - B. I and III only
  - C. II and III only
  - D. I, II and III

13. [1 mark]

Which does **not** show resonance?

- A.  $PO_4^{3-}$
- B.  $C_6H_6$
- C.  $C_6H_{12}$
- D.  $O_3$

14. [6 marks]

SF<sub>2</sub>, SF<sub>4</sub> and SF<sub>6</sub> have different shapes. Draw their Lewis structures and use the VSEPR theory to predict the name of the shape of each molecule.

	SF <sub>2</sub>	SF <sub>4</sub>	SF <sub>6</sub>
Lewis structure			
Name of shape	.....	.....	.....

15a. [3 marks]

Draw the Lewis structures, state the shape and predict the bond angles for the following species.



15b. [3 marks]



15c. [3 marks]



**16a.** [3 marks]

Nitrogen and silicon belong to different groups in the periodic table.

Draw the Lewis structures, state the shapes and predict the bond angles for the following species.



**16b.** [3 marks]



**16c.** [3 marks]

Explain, using diagrams, why  $\text{NO}_2$  is a polar molecule but  $\text{CO}_2$  is a non-polar molecule.

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**17a.** [4 marks]

When iodine reacts with excess chlorine,  $\text{ICl}_3$  can form. Deduce the Lewis (electron dot) structure of  $\text{ICl}_3$  and  $\text{ICl}_2^-$  and state the name of the shape of each species.

	$\text{ICl}_3$	$\text{ICl}_2^-$
Lewis structure		
Name of shape		

**17b.** [1 mark]

In this project the students explored several aspects of the chemistry of the halogens. In the original preparation of  $\text{ICl(l)}$ , they observed the yellow-green colour of chlorine gas,  $\text{Cl}_2(\text{g})$ , reacting with solid iodine,  $\text{I}_2(\text{s})$ .

State the **full** electron configuration of iodine ( $Z = 53$ ).

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18. [6 marks]

Draw the Lewis structures, predict the shape and deduce the bond angles for xenon tetrafluoride and the nitrate ion.

Species	Lewis structure	Shape	Bond angle
$\text{XeF}_4$			
$\text{NO}_3^-$			

19. [2 marks]

Calcium nitrate contains both covalent and ionic bonds.

Bonding in the nitrate ion involves electron delocalization. Explain the meaning of electron delocalization and how it affects the ion.

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20a. [1 mark]

The element boron has two naturally occurring isotopes,  $^{10}\text{B}$  and  $^{11}\text{B}$ .

Phosphorus forms two chlorides,  $\text{PCl}_3$  and  $\text{PCl}_5$ .

Apply the Aufbau principle to state the **full** electron configuration for an atom of phosphorus.

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**20b. [2 marks]**

Deduce the Lewis structures for  $\text{PCl}_3$  and  $\text{PCl}_5$ .

$\text{PCl}_3$  \_\_\_\_\_  $\text{PCl}_5$

**20c. [4 marks]**

Predict the shapes and the bond angles in the two molecules.

	$\text{PCl}_3$	$\text{PCl}_5$
Shape	..... .....	..... .....
Bond angles	..... .....	..... .....

**20d. [1 mark]**

Identify the type of hybridization present in  $\text{PCl}_3$ .

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**20e.** [3 marks]

Compare the melting points of  $\text{PCl}_3$  and  $\text{PCl}_5$  and explain the difference.

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**21a.** [3 marks]

Phosphoryl chloride,  $\text{POCl}_3$ , is a dehydrating agent.

State and explain the Cl-P-Cl bond angle in  $\text{PCl}_3$ .

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**21b.** [1 mark]

$\text{POCl}_3$  can be prepared by the reaction of phosphorus pentachloride,  $\text{PCl}_5$ , with tetraphosphorus decaoxide,  $\text{P}_4\text{O}_{10}$ .

Deduce the Lewis (electron dot) structure of  $\text{PCl}_5$ .

**21c.** [1 mark]

Predict the shape of this molecule, using the valence shell electron pair repulsion theory (VSEPR).

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**21d.** [1 mark]

Identify all the different bond angles in  $\text{PCl}_5$ .

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**22a.** [2 marks]

Ozone,  $\text{O}_3$ , in the upper atmosphere prevents harmful UV radiation reaching the surface of the Earth.

State the shape of the ozone molecule and estimate the bond angle.

Shape:

Bond angle:

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**22b.** [1 mark]

State the hybridization of the central oxygen atom.

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**22c.** [2 marks]

The two oxygen-oxygen bonds in ozone are in fact of equal length. Deduce why this is the case and how the length of these would compare to oxygen-oxygen bond lengths in hydrogen peroxide,  $\text{H}_2\text{O}_2$ , and in the oxygen molecule,  $\text{O}_2$ .

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**23.** [2 marks]

Describe the formation of  $\sigma$  and  $\pi$  bonds in an alkene.

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24a. [2 marks]

Consider the molecules  $\text{PBr}_3$  and  $\text{SF}_4$ .

Deduce the Lewis (electron dot) structure of both molecules.

24b. [4 marks]

Predict the shapes of the two molecules, giving the Br–P–Br bond angle in  $\text{PBr}_3$  and the F–S–F bond angles in  $\text{SF}_4$ .

$\text{PBr}_3$	$\text{SF}_4$
Shape: ..... .....	Shape: ..... .....
Bond angle: ..... .....	Bond angles: ..... .....

24c. [2 marks]

Explain why both  $\text{PBr}_3$  and  $\text{SF}_4$  are polar.

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