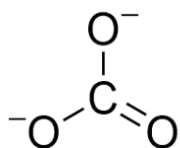
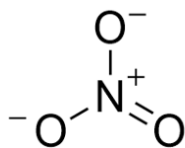
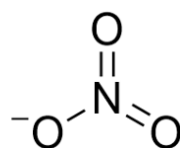
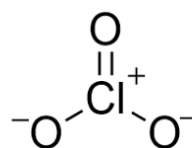
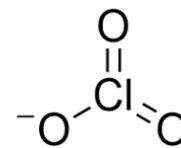


DO NOT BEGIN UNTIL TOLD TO DO SO BY THE INVIGILATOR

This test consists entirely of multiple choice questions and is worth 25 marks. There is one mark per question. The answers for the 25 questions must be coded on the optical sense form (bubble sheet) using a **PEN** or **SOFT PENCIL**. Select the **BEST** response for each question below.

1. The following Lewis structures are shown without non-bonding electrons, but with their formal charges. Which of the following Lewis structures is invalid? That is, which one cannot be a valid Lewis/resonance structure in a description of the bonding in that species? **Answer is C**

**A****B****C****D****E**

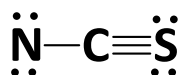
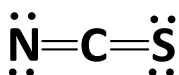
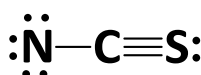
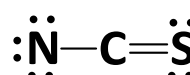
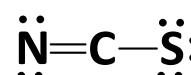
2. Which **ONE** of the following molecules obeys the octet rule for all atoms?

A. PF₅B. BH₃

C. NO

D. XeF₂E. SiBr₄

3. Which one of the following resonance structures of NCS⁻ is most important in describing the bonding in the real molecule? **Answer is B**

**A****B****C****D****E**

4. Calculate the overall change in energy (*i.e.* change in enthalpy, change in heat, ΔH_{rxn} in kJ mol⁻¹) for the reaction N₂ (g) + 3H₂ (g) → 2NH₃ (g).

A. -87

B. 87

C. 1077

D. 1209

E. -869

5. Which of the following ions does NOT exhibit any bond orders greater than 1?

A. CO₃²⁻B. NO₃⁻C. OCN⁻D. BF₄⁻E. HCO₂⁻

6. Considering likely intermolecular forces, which of the following should have the highest boiling point?

- A. $\text{CH}_3\text{-O-CH}_3$ B. $\text{CH}_3\text{CH}_2\text{OH}$ C. $\text{CH}_3\text{CH}_2\text{CH}_3$ D. $\text{CH}_3\text{CH}_2\text{SH}$ E. $\text{CH}_2=\text{N-CH}_3$

7. Predict the shape of the XeO_4 molecule.

- A. trigonal planar B. tetrahedral C. trigonal bipyramidal D. see saw E. square planar

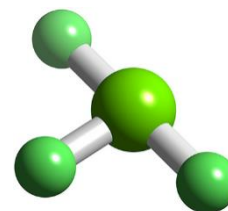
8. Which element M will lead to an MF_4 molecule with square planar molecular geometry?

- A. Xe B. Ga C. Sn D. Se E. Si

9. Which of the following anions has **ONLY ONE** non-bonded pair of electrons (lone pair) on the **chlorine**?

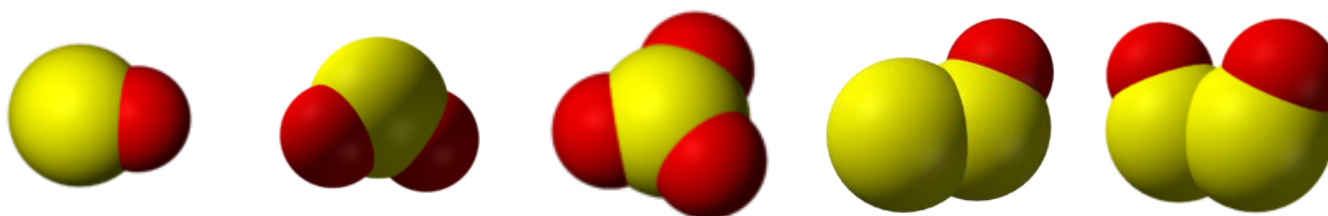
- A. Cl^- B. ClO^- C. ClO_2^- D. ClO_3^- E. ClO_4^-

10. The structure shown is a representation of which molecule?



- A. GaBr_3 B. PCl_3 C. BF_3 D. AsH_3 E. IF_3

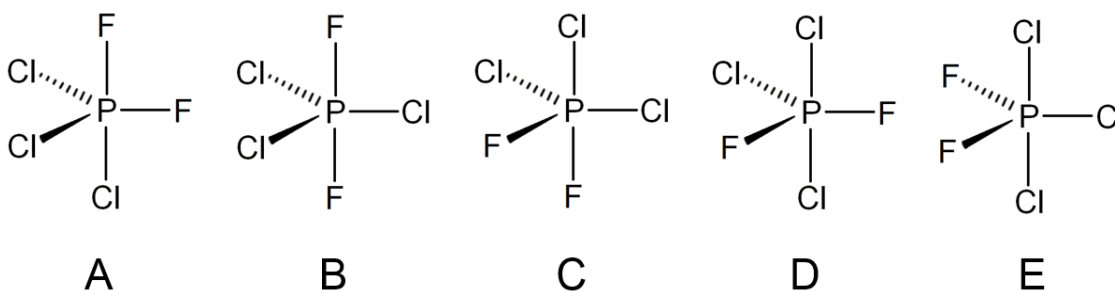
11. Which of these molecules is non-polar?



A. SO

B. SO₂C. SO₃D. S₂OE. S₂O₂

12. Which of the trigonal bipyramidal PCl₃F₂ structures below is non-polar? Answer = B



A

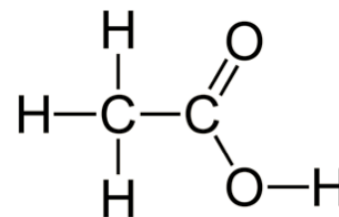
B

C

D

E

Questions 13-19 concern the molecule acetic acid, C₂H₄O₂ (structure shown at the right). Lone pairs are not shown.



13. How many non-bonding valence electrons are there in a molecule of acetic acid?

A. 0

B. 2

C. 4

D. 6

E. 8

14. The O-C-O and C-O-H bond angles in a molecule of acetic acid are closest to what pair of values, respectively?

A. 120°, 109.5°

B. 120°, 120°

C. 109.5°, 120°

D. 109.5°, 109.5°

E. 120°, 90°

15. How many sp² hybrid orbitals are there in a molecule of acetic acid?

A. 1

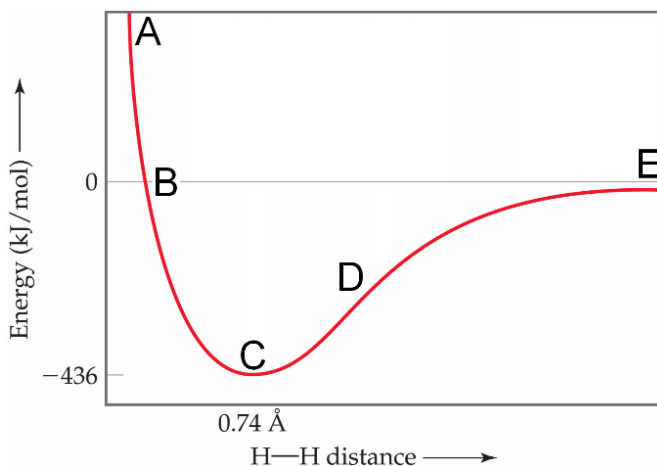
B. 2

C. 3

D. 4

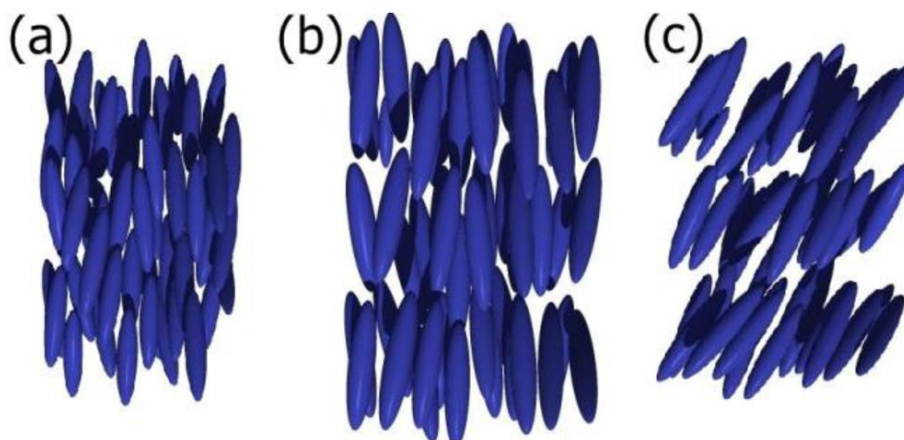
E. 6

16. How many sp^3 hybrid orbitals are there in a molecule of acetic acid?
- A. 2 B. 4 C. 6 D. 8 E. 16
17. A molecule of acetic acid has how many sigma (σ) and how many pi (π) bonds?
- A. 5 σ , 1 π B. 6 σ , 1 π C. 6 σ , 2 π D. 7 σ , 1 π E. 7 σ , 2 π
18. Acetic acid has a melting point of 16°C and a boiling point of 118°C at standard atmospheric pressure. At a room temperature of 25°C , what phase is it in?
- A. gas B. liquid C. liquid crystal D. supercritical fluid E. ionic liquid
19. Acetic acid mixes with water in all proportions primarily due to what type of intermolecular force?
- A. ionic bonding B. ion-dipole C. dipole-dipole D. hydrogen bonding E. London dispersion
20. A plot of change in potential energy versus distance for two H atoms combining to form H_2 is shown below. At what point (A, B, C, D or E) is the electrostatic repulsion between nuclei highest? Answer=A
This question will be omitted because the answer was accidentally given. Test is out of 24.



21. What is the bond order in the HHe molecule?
- A. 0 (no reaction) B. 0.5 C. 0.75 D. 1 E. 2
22. Which of the following metals has the highest melting point?
- A. Rb B. Y C. Mo D. Ag E. Cd

23. Which of the sketches below depicts a smectic liquid crystal phase?



A. A

B. B

C. C

D. B and C

E. all of them

24. Why do ionic liquids have a low melting point?

- A. Low molecular weight
- B. No ionic bonding
- C. Low lattice energy due to shape mismatch between cation and anion
- D. Ordered phases above the melting point
- E. Absence of hydrogen bonding

25. Which ONE of the following pairs of **molecule** and **intermolecular force** is CORRECT?

- A. Benzene (C_6H_6), dipole-dipole
- B. CF_4 , only London dispersion
- C. CH_3CN , hydrogen bonding
- D. PF_3 , only London dispersion
- E. CaF_2 , dipole-dipole

END