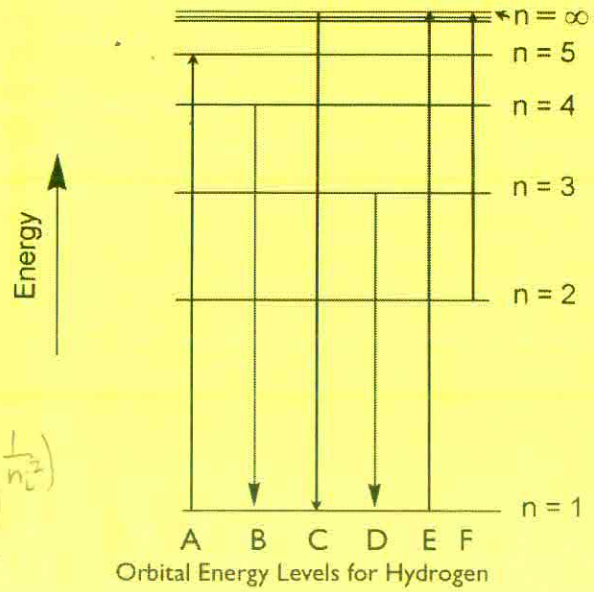
This test consists entirely of multiple choice questions and is worth 50 marks. There are two marks per question. The answers for the 25 questions must be coded on the optical sense form (bubble sheet) using a PEN or *SOFT PENCIL*.

Select the* BEST *response for each question below.

Below is the energy level diagram for the possible energy levels of a hydrogen atom. (not to scale). Answer the following questions 1 to 4 about the hydrogen atom.

1. What is the energy change (ΔE) corresponding to the transition labeled F?
   A. -1.63×10^{-18} J
   B. 5.45×10^{-17} J
   C. 2.18×10^{-18} J
   D. 1.63×10^{-18} J
   E. -5.45×10^{-17} J

Question omitted
No right answer



Orbital Energy Levels for Hydrogen

2. What is the wavelength of light emitted by the transition labeled D?
   A. 1.03×10^{-7} nm
   B. 2.92×10^{-15} nm
   C. 103 nm
   D. 1.03 nm
   E. 137 nm

$E = -2.18 \times 10^{-18}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$
$= -2.18 \times 10^{-18}\left(1 - \frac{1}{4}\right)$
$= -1.9377 \times 10^{-18}$

$E = h\nu$
$E = \frac{hc}{\lambda}$
$\lambda E = hc$ $\lambda = \frac{hc}{E}$ $\lambda = \frac{6.63 \times 10^{-34} \cdot 3.00 \times 10^{8}}{-1.9377 \times 10^{-18}}$

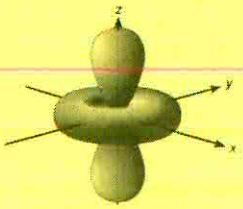
1.03×10^{-7}

3. Consider the following chemical equation: $H(g) \rightarrow H^{+}(g) + e^{-}$
   Which of the transition arrows in the above energy level diagram best describes the energy change for this reaction?

4. Decide whether the following statements are true (T) or false (F) and then select the best response below (A-E) for indicating all those that are FALSE.
   i) Transition B represents an emission.
   ii) Transition F represents an ionization.
   iii) Transition B represents an absorption.
   iv) Transition E involves a greater energy change than transition F.
   v) Transition A takes the electron to the 5th excited state.
   vi) Transition C represents the lattice energy of H.

A. v & vi B. i, ii, & iv C. ii, iii & vi D. iii, v & vi E. iii & vi

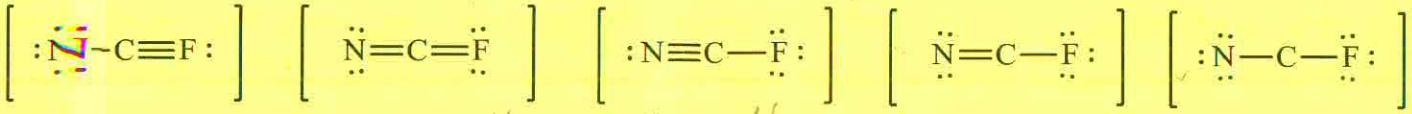
5. Which atomic orbital is described by the shape shown at the right?



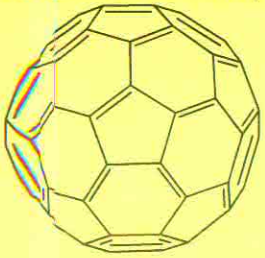
A. 1s
B. 2s
C. 2p
D. 3d
E. 4f

6. Which of these (below) is the best Lewis structure for the NCF molecule?

A B C D E



7. In 1999 scientists published the measurement of an interference pattern that demonstrated the de Broglie wavelength of C_{60} (buckyball, mass 1.2×10^{-24} kg). What is the frequency (ν) of the de Broglie wave that corresponds to a buckyball moving at a velocity of 220 m/s?



C_{60} Buckyball

A. $1.2 \times 10^{20}\ s^{-1}$
B. $2.5 \times 10^{-12}\ s^{-1}$
C. $5.4 \times 10^{17}\ s^{-1}$
D. $8.3 \times 10^{-21}\ s^{-1}$
E. $4.0 \times 10^{11}\ s^{-1}$

8. Which atomic orbital is described by the quantum numbers n = 4, ℓ = 2, m_ℓ = 1?

A. 4s
B. 4p
C. 4d
D. 4f
E. 4g

9. Which of the following sets of quantum numbers describes a valence electron of a chlorine atom?

A. n = 2, ℓ = 1, m_ℓ = 1, m_s = +1/2
B. n = 3, ℓ = 0, m_ℓ = 0, m_s = +1/2
C. n = 3, ℓ = 1, m_ℓ = 2, m_s = -1/2
D. n = 2, ℓ = 1, m_ℓ = -1, m_s = -1/2
E. n = 4, ℓ = 2, m_ℓ = -2, m_s = -1/2

10. Consider the Lewis structure of $HOClO_2$ in which O and Cl obey the octet rule (H is bonded to one O atom and all three O atoms are bonded to chlorine). Which **one** of the following statements is **INCORRECT**?

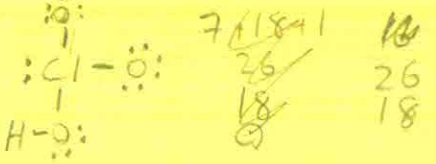
A. The O atom bonded to the H atom has two nonbonded pairs of electrons.

B. The O atoms that are not bonded to the H atom have three non-bonded pairs of electrons each.

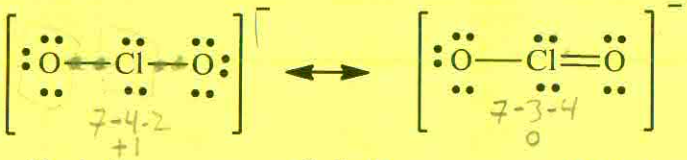
C. The O to Cl bonds are double bonds.

D. The H to O bond is a single bond.

E. Cl has one lone pair of electrons.



11. The formal charges on the Cl atoms in the two resonance forms of $[ClO_2]^-$ are, respectively



A. +1, 0 B. -1, 0 C. 0, 0 D. 0,+1 E. 0, -1

12. Which of these ionic compounds has the largest lattice energy?

A. KCl B. $CaCl_2$ C. $ScCl_3$ D. CaO E. Sc_2O_3

13. Using the notation n, ℓ, m_ℓ, m_s, which of the following sets of four quantum numbers never occurs for any electron in a ground state ruthenium (Ru) atom?

A. 4, 2, -1, -1/2
B. 5, 1, -1, +1/2
C. 2, 1, 0, -1/2
D. 5, 0, 0, -1/2
E. 3, 2, +2, -1/2

14. If A > B means the radius of A is greater than the radius of B, then which of the following comparisons is INCORRECT?

A. $C > C^+$ B. S > O C. As > S D. $Rb^+ > Br^-$ E. $Rb^+ > Sr^{2+}$

15. If A > B means the first ionization energy (I_1) of A is greater than the first ionization energy of B, then which of the following comparisons is INCORRECT?

A. S > Si B. Be > B C. C > Si D. S > Se E. S > O

16. Identify the species in the following list that has the largest radius.

A. Li^+ B. O^{2-} C. Se^{2-} D. Br^- E. Ne

17. Identify the atom in the following list that has the lowest electronegativity.

A. K B. Se C. Ca D. N E. Li

18. Identify the atom in the following list in which the valence electron(s) experience the highest effective nuclear charge.

A. H B. He C. Li D. Be E. B

$1s^2 2s^2 2p^1$

2-0 3-2 4-2=2 5-2=3

19. How many bonds are drawn in the best Lewis structure for NO_2^+ ?

A. 2 B. 3 C. 4 D. 5 E. 6

16 12 0

6-6=0 4-4=0

20. The Sabatier reaction (shown below) is being used in pilot plants to generate methane fuel and consume waste carbon dioxide from industry. The process is useful where there is excess available energy, such as from wind turbines at night when public and industrial demand for electricity is lower. Using bond energies from the Data Sheet, calculate an approximate value for the enthalpy of reaction ($\Delta H_{reaction}$) for this process.

$$O{=}C{=}O + 4\,H_2 \xrightarrow[\text{Ni catalyst}]{\text{heat}} \underset{\text{methane}}{\begin{array}{c} H \\ | \\ H{-}C{-}H \\ | \\ H \end{array}} + 2\,H_2O$$

A. +742 B. −349 C. −264 D. −192 E. −742

Break

2 O=C 800

4 H-H 432

3328

Form

4 C-H 413

4 O-H 467

3520

21. Which of the following species has the electron configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^3$

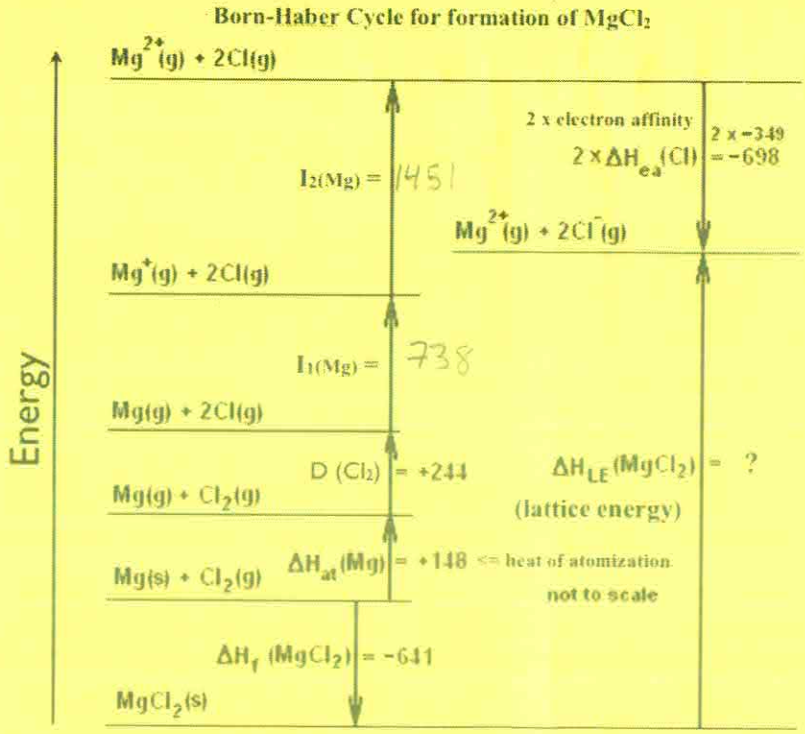
A. As^+ B. Se^+ C. Ge^{2-} D. P E. Sb

22. With reference to the Data Sheet, the energy change (enthalpy change, heat change) for the reaction $Ca^+(g) + e^- \rightarrow Ca(g)$ is_____ kJ mol^{-1}.

A. +590 B. −2 C. −503 D. −590 E. +503

23. The following figure is a graph of the Born-Haber cycle for magnesium chloride ($MgCl_2$). It is not drawn to scale. The energy units are kJ mol^{-1}. (Atomization refers to the vaporization or sublimation of metallic magnesium.)

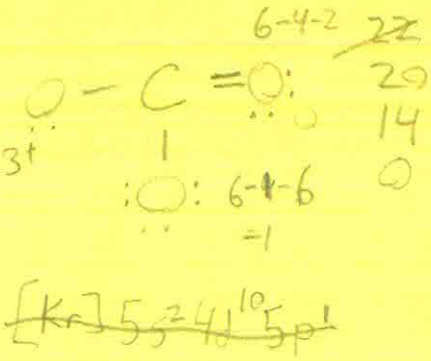
Using this Born-Haber cycle and information from the Data Sheet, calculate the lattice energy of $MgCl_2$ in kJ mol^{-1}.



A. 2490 B. 1811 C. 2524 D. 2255 E. 1242

24. How many lone pairs of electron are drawn in the best Lewis structure for CO_3^{2-} ?

A. 8 B. 7 C. 6 D. 5 E. 4



25. What is the electron configuration for In^{3+}?

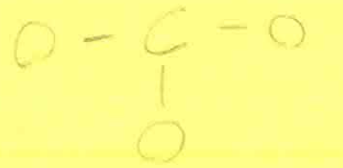
A $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6 5s^2\ 4d^8$

B $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^3\ 4d^{10}$

C $[Kr]\ 5s^2\ 4d^{10}\ 5p^1$

D $[Ar]\ 4d^{10}$

E $[Kr]\ 4d^{10}$



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