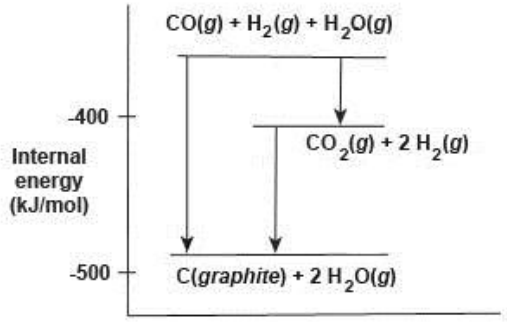
1. Consider a chemical process that changes the internal energy of a system without performing pressure-volume work (i.e. $P\Delta V = 0$). The change in internal energy (ΔE) is ____ the change in enthalpy (ΔH).

A. greater than
B. less than
C. equal to
D. unrelated to

2. According to the energy level diagram on the right, which statement is **true** at constant pressure?



A. $C(graphite) + H_2O(g) \rightarrow CO(g) + H_2(g)$ is an exothermic reaction.
B. The reaction $CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O(g)$ releases heat to its surroundings.
C. $CO_2(g) + 2\ H_2(g) \rightarrow C(graphite) + 2\ H_2O(g)$ is an endothermic reaction.
D. The enthalpy change for $CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$ is negative.

3. The combustion of 11.5 g of H_2S releases 240. kJ of energy. What is ΔH for the reaction below?

$$2\ H_2S + 3\ O_2 \rightarrow 2\ SO_2 + 2\ H_2O$$

A. −4530 kJ
B. −1420 kJ
C. −625 kJ
D. 115 kJ

4. Given

$$SO_2(g) + Cl_2(g) \rightarrow SO_2Cl_2(g) \qquad \Delta H = -68 \text{ kJ},$$

what is the enthalpy change for the following reaction?

$$2\ SO_2Cl_2(g) \rightarrow 2\ SO_2(g) + 2\ Cl_2(g)$$

A. 136 kJ
B. 68 kJ
C. −34 kJ
D. −136 kJ

5. Calculate ΔH_{rxn} for the reaction:

$$P_4(g) + 10\ Cl_2(g) \rightarrow 4\ PCl_5(s)$$

Use the following reactions and ΔH values.

$PCl_5(s) \rightarrow PCl_3(g) + Cl_2(g)$ $\Delta H°_{rxn} = +157$ kJ

$P_4(g) + 6\ Cl_2(g) \rightarrow 4\ PCl_3(g)$ $\Delta H°_{rxn} = -1207$ kJ

A. −628 kJ
B. −1050 kJ
C. −1207 kJ
D. −1835 kJ

6. For which of the following equations does $\Delta H°_{reaction} = \Delta H°_{formation}$ of $NaHCO_3$?

A. $Na(s) + HCO_3(aq) \rightarrow NaHCO_3(s)$
B. $Na^+(aq) + HCO_3^-(aq) \rightarrow NaHCO_3(s)$
C. $Na(s) + H(g) + C(s) + 3O(g) \rightarrow NaHCO_3(s)$
D. $Na(s) + ½\ H_2(g) + C(s) + 3/2\ O_2(g) \rightarrow NaHCO_3(s)$

7. ΔH^{o}_{rxn} of the following reaction is −8326.0 kJ.

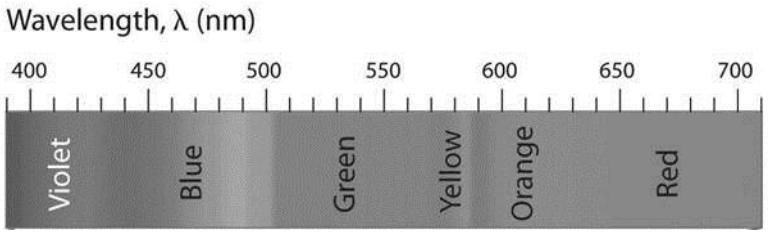
$$2\ C_6H_{14}(l) + 19\ O_2(g) \rightarrow 12\ CO_2(g) + 14\ H_2O(l)$$

What is ΔH^{o}_{f} of $C_6H_{14}(l)$ given the following data?

	ΔH^{o}_{f}
$CO_2(g)$	−393.5 kJ/mol
$H_2O(l)$	−285.8 kJ/mol

A. 397.2 kJ/mol
B. 99.3 kJ/mol
C. −198.6 kJ/mol
D. −794.4 kJ/mol

8. Which type of visible light has photons with the **highest** energy?



A. red light
B. orange light
C. blue light
D. violet light

9. When strontium salts are heated, they emit light with a wavelength of 650 nm, which gives fireworks their brilliant red color. Calculate the **frequency** of light with a wavelength of 650 nm.

A. 4.62×10^{14} Hz
B. 1.95×10^{11} Hz
C. 4.62×10^{5} Hz
D. 3.06×10^{-19} Hz

10. Calculate the **energy** of a photon of green light ($\lambda = 525$ nm).

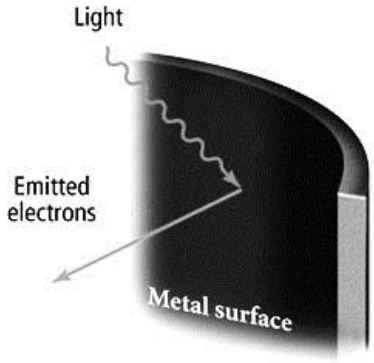
A. 3.48×10^{-31} J

B. 3.79×10^{-28} J

C. 3.79×10^{-19} J

D. 5.71×10^{14} J

11. A metal surface is irradiated with light from lasers X, Y, and Z, each with a different wavelength. Laser X produced photoelectrons with a kinetic energy of 95 kJ/mol, laser Y produced photoelectrons with a kinetic energy of 165 kJ/mol, and laser Z produced no photoelectrons. Arrange the lasers in order of **increasing wavelength**.



A. Y < X < Z

B. Z < X < Y

C. X < Y < Z

D. Z < Y = X

12. Which statement is part of Bohr's model that explains emission and absorption atomic spectra?

A. An atom absorbs light when an electron is located between two fixed orbits.

B. An atom emits light when an electron moves around the nucleus within its orbit.

C. An atom emits light when an electron drops from a higher to a lower orbit.

D. An excited atom can emit any frequency of visible light.

13. What is the **speed** of an electron (mass = 9.11×10^{-28} g) with a de Broglie wavelength of 0.25 nm?

A. 2.9×10^{6} m/s

B. 1.8×10^{5} m/s

C. 2.9×10^{3} m/s

D. 1.8×10^{2} m/s

14. Heisenberg's uncertainty principle states that

A. an electron is an entity that is intermediate between a particle and a wave.

B. the more accurately we know the position of a particle, the less accurately we can know the velocity of that particle.

C. for a moving particle, $\Delta x \times m\Delta v < h/4\pi$, where Δx is uncertainty in position, m is mass, Δv is uncertainty in velocity, and h is Planck's constant.

D. the observation of an event has no effect on its outcome.

15. Select the **true** statement about the quantum-mechanical description of an atom.

A. Each atomic orbital can hold only one electron.

B. An atomic orbital describes the three-dimensional distribution of an electron in space as defined by a set of quantum numbers.

C. An orbital describes the circular orbit that an electron follows around the nucleus.

D. Superimposing the electron density in a filled set of *s*, *p* and *d* orbitals results in a cubic distribution of electron density.

16. The **principal** quantum number determines an atomic orbital's

A. angular momentum.

B. overall size.

C. orientation in space.

D. electron spin.

17. Which value of m_l is **not** allowed for a 4*d* orbital?

A. −1

B. 0

C. 2

D. 4

18. Which set of quantum numbers **cannot** occur together to specify an orbital?

A. $n = 3, l = 2, m_l = 1$

B. $n = 8, l = 5, m_l = -5$

C. $n = 7, l = 7, m_l = -4$

D. $n = 6, l = 5, m_l = 0$

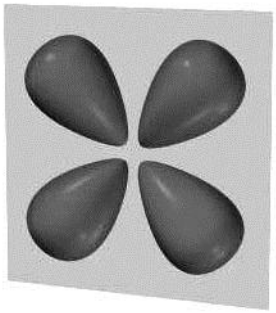
19. What **wavelength** of light is emitted when a hydrogen electron moves from the $n = 4$ to the $n = 2$ state?

A. 364 nm
C. 831 nm
B. 486 nm
D. 1108 nm

20. Which orbitals do the **valence** electrons of a ground-state aluminum atom occupy?

A. 3*s*, 3*p*, 3*d*
C. 3*s*, 3*p*, 2*d*
B. 2*s*, 2*p*
D. 3*s*, 3*p*

21. The figure shows which type of orbital?



A. *s*
C. *d*
B. *p*
D. *f*

22. How many **unpaired** electrons does a ground-state boron atom have?

A. 1
C. 3
B. 2
D. 4

23. Which statement is correct about a **multielectron atom**?

A. Orbital energies increase in the order $3s < 3p < 3d$ because orbital penetration decreases in the order $3s > 3p > 3d$.

B. Orbital energies increase in the order $3s < 3p < 3d$ because the Schrödinger equation predicts that orbital energy depends only on the angular momentum quantum number, l.

C. Orbital energies increase in the order $3d < 3p < 3s$ because the effective nuclear charge experienced by an electron increases in the order $3s < 3p < 3d$.

D. $3s$, $3p$ and $3d$ orbitals are energetically degenerate because orbital energy depends only on the principal quantum number, n.

24. What is the electron configuration of a ground-state Co atom?

A. [Kr] $4s^2\,3d^7$

B. [Ar] $4s^2\,3d^7$

C. [Ar] $4s^1\,3d^8$

D. [Ar] $4s^2\,4d^7$

25. Which of the following statements is **true** for elements with the valence electron configuration ns^2np^5?

A. They are metals.

B. They are strong oxidizing agents.

C. They have small first ionization energies.

D. They typically form +1 ions.

26. In which series are the atoms arranged in order of **decreasing** (highest to lowest) effective nuclear charge experienced by their valence electrons?

A. S > Si > Al > Mg

B. Si > S > Mg > Al

C. Mg > Al > Si > S

D. Al > Mg > S > Si

27. Which one of the following has the **largest** atomic radius?

A. Ca
B. K^+
C. K
D. Na

28. Which of the following describes the general trend in **first ionization energy** across a row of the periodic table?

A. It varies almost randomly.
B. It is essentially constant.
C. It decreases from left to right.
D. It increases from left to right.

29. Moving **down** a column (group) in the *s* or *p* block of the periodic table, metallic character

A. decreases.
B. increases.
C. remains constant.
D. varies unpredictably.

30. In the sixth row of the periodic table (beginning with Cs), electrons fill only

A. 6*s*, 6*p*, 6*d* and 6*f* orbitals.
B. 6*s*, 6*p* and 5*d* orbitals.
C. 6*s*, 6*p*, 5*d* and 4*f* orbitals.
D. 6*s*, 5*p*, 4*d* and 3*f* orbitals.

Answer Key:

1. C
2. D
3. B
4. A
5. D
6. D
7. C
8. D
9. A
10. C
11. A
12. C
13. A
14. B
15. B
16. B
17. D
18. C
19. B
20. D
21. C
22. A
23. A
24. B
25. B
26. A
27. C
28. D
29. B
30. C