Useful Information:	$h = 6.626 \times 10^{-34}$ J·s $c = 2.998 \times 10^{8}$ m·s^{-1} 1 J = 1 kg·m^{2}s^{-2} $N_A = 6.022 \times 10^{23}$ $R_H = 2.179 \times 10^{-18}$ J

1. Place the following regions of the electromagnetic spectrum in order of increasing wavelength:
   microwaves, orange light, X rays, red light

   a) red light < orange light < microwaves < X rays
   b) orange light < red light < microwaves < X rays
   c) X rays < microwaves < red light < orange light
   d) microwaves < red light < orange light < X rays
   e) X rays < orange light < red light < microwaves

2. The MRI (magnetic resonance imaging) body scanners used in hospitals operate with 400 MHz radiofrequency energy. How much energy does this correspond to in kilojoules per mole?
   a) 2.65×10^{-28} kJ/mol
   b) 4.40 kJ/mol
   c) 4.40×10^{-3} kJ/mol
   d) 1.60×10^{-7} kJ/mol
   e) 1.60×10^{-4} kJ/mol

3. The greater the energy of a photon, the
   a) longer the wavelength and the higher the frequency
   b) longer the wavelength and the lower the frequency
   c) shorter the wavelength and the higher the frequency
   d) shorter the wavelength and the lower the frequency

4. Excited rubidium atoms emit red light with a wavelength of 795 nm. What is the energy, in kilojoules per mole, of this electromagnetic radiation?
   a) 150 kJ/mol
   b) 4.15 kJ/mol
   c) 27.8 kJ/mol
   d) 72.1 kJ/mol
   e) 14.2 kJ/mol

5. What wavelength of light is emitted by a hydrogen atom when an electron makes a transition from the n=3 energy state to the n=2 energy state?

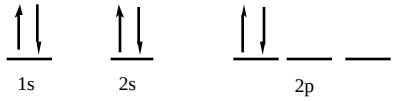
   a) 486 nm
   b) 656 nm
   c) 954 nm
   d) 97.3 nm
   e) 152 nm

6. The Balmer series consists of several visible lines in the hydrogen emission spectrum. Lines in the Balmer series result when an electron in a higher energy shell makes a transition to the n=2 shell. The Lyman series consists of several lines that result when a hydrogen electron makes a transition from a higher energy shell to the n=1 shell. In what portion of the electromagnetic spectrum would you expect to see the Lyman series?

   a) infrared
   b) ultraviolet
   c) microwave
   d) radio wave
   e) any of these

7. What is the de Broglie wavelength, in nanometers, associated with an electron that is moving with a velocity of 5.97×10^{6} m/s? (The mass of an electron is 9.11×10^{-28} g.)
   a) 0.595 nm
   b) 52.7 nm
   c) 122 nm
   d) 0.122 nm
   e) 7.11 nm

8. The electron configuration shown below is incorrect because it violates:



   a) the Heisenberg Uncertainty Principle
   b) Hund's Rule
   c) the Pauli exclusion principle
   d) the aufbau principle
   e) the de Broglie wavelength

9. Which of the following sets of quantum numbers is not allowed?
   a) $n = 1$, $l = 0$, $m_l = 0$, $m_s = -1/2$
   b) $n = 2$, $l = 0$, $m_l = 0$, $m_s = +1/2$
   c) $n = 2$, $l = 1$, $m_l = 0$, $m_s = +1/2$
   d) $n = 2$, $l = 2$, $m_l = 0$, $m_s = +1/2$
   e) choices b and d

10. The number of orbitals in a given subshell, such as the 5d subshell, is determined by the number of possible values of
    a) n
    b) l
    c) m_l
    d) m_s

11. What is/are the angular momentum quantum number(s) for the highest energy electrons in a ground state argon atom?
    a) 1
    b) 2
    c) 0, 1, 2
    d) -1, 0, +1
    e) -2, -1, 0, +1, +2

12. What is/are the possible magnetic quantum number(s) for the highest energy electrons in a ground state phosphorus atom?
    a) -1, 0, +1
    b) -2, -1, 0, +1, +2
    c) 0, 1, 2
    d) 0
    e) 1

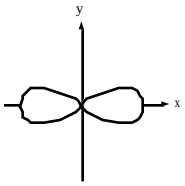
13. According to the aufbau principle, which orbital is filled immediately after a 3d subshell is filled in a multielectron atom?
    a) 3p
    b) 4s
    c) 4p
    d) 4d
    e) 3f

14. What is the ground state electron configuration for a bromine atom?
    a) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$
    b) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4d^{10} 4p^5$
    c) $1s^2 2s^2 3s^2 3p^6 4s^2 4p^6 4d^{10} 5s^2 5p^3$
    d) $1s^2 1p^6 2s^2 2p^6 2d^{10} 3s^2 3p^6 3d^1$
    e) $1s^2 2s^2 2p^2 3s^2 3p^2 3d^2 4s^2 4p^2 4d^2 4f^2$

15. What is the electron configuration of radon (Rn, atomic number 86)?
    a) [Xe] $6s^2\ 5p^6$
    b) [Xe] $6s^2\ 5f^{14}\ 5d^{10}\ 6p^6$
    c) [Xe] $6s^2\ 5d^{10}\ 6p^6$
    d) [Xe] $6s^2\ 4f^{14}\ 5d^{10}\ 6p^6$
    e) [Xe] $6s^2\ 4f^{10}\ 5d^{14}\ 6p^6$

16. How many unpaired electrons are present in nickel atom?
    a) 0
    b) 3
    c) 5
    d) 2
    e) 4

17. What type of orbital is shown below?



    a) 1s
    b) 2s
    c) $2p_x$
    d) $1p_x$
    e) $3d_x$

18. The energy change that occurs when an electron is added to a gaseous atom is referred to as

    a) electron affinity
    b) lattice energy
    c) ionization energy
    d) electronegativity
    e) bond dissociation energy

19. Place the following atoms in order of <u>increasing</u> first ionization energy: Be, B, N, O.

    a) B < Be < O < N
    b) O < N < B < Be
    c) Be < B < N < O
    d) Be < B < O < N
    e) N < O < B < Be

20. Which of the following statements is <u>true</u>?

    a) The first ionization energy of Na is greater than the first ionization energy of Li.
    b) The first ionization energy of Al is greater than the first ionization energy of Mg.
    c) The third ionization energy of Li is greater than the third ionization energy of Be.
    d) The second ionization energy of Li is greater than the second ionization energy of Be.
    e) The second ionization energy of Na is greater than the third ionization energy of Mg.

21. Which substance below has the highest fourth ionization energy?

    a) B
    b) C
    c) N
    d) O
    e) impossible to predict

22. Which of the following elements has the greatest (i.e., the most negative) electron affinity?

    a) Li
    b) Be
    c) B
    d) N
    e) F

23. Which of the following elements is most likely to have a positive electron affinity?

    a) Be
    b) Ne
    c) Li
    d) choices a and b
    e) choices a, b, and c

24. The equation for the standard enthalpy of formation of N_2O_3 is
    a) $N_2O(g) + O_2(g) \rightarrow N_2O_3(g)$
    b) $N_2(g) + O_3(g) \rightarrow N_2O_3(g)$
    c) $2\ N(g) + 3\ O(g) \rightarrow N_2O_3(g)$
    d) $N_2(g) + 3/2\ O_2(g) \rightarrow N_2O_3(g)$
    e) $2\ N_2(g) + 3\ O_2(g) \rightarrow 2\ N_2O_3(g)$

25. Given the enthalpy changes for the following reactions:

$2ClF(g) + O_2(g) \rightarrow Cl_2O(g) + F_2O(g)$ $\quad \Delta H = 167.4$ kJ
$2ClF_3(g) + 2O_2(g) \rightarrow Cl_2O(g) + 3F_2O(g)$ $\quad \Delta H = 341.4$ kJ
$2F_2(g) + O_2(g) \rightarrow 2F_2O(g)$ $\quad \Delta H = -43.4$ kJ

Calculate the enthalpy change, ΔH, for the following reaction:

$ClF(g) + F_2(g) \rightarrow ClF_3(g)$

    a) -217.5 kJ
    b) –130.2 kJ
    c) –108.7 kJ
    d) 130.2 kJ
    e) 217.5 kJ

26. The standard enthalpy change for the oxidation of ammonia is –905.2 kJ:

$$4NH_3(g) + 5\,O_2(g) \rightarrow 4NO(g) + 6H_2O(g) \qquad \Delta H = -905.2 \text{ kJ}$$

Calculate the standard molar enthalpy of formation for ammonia based on the following standard enthalpies of formation:

$$\Delta H°_f\,[NO(g)] = +90.3 \text{ kJ/mol}$$
$$\Delta H°_f\,[H_2O(g)] = -241.8 \text{ kJ/mol}$$

a) -46.1 kJ/mol
b) –92.2 kJ/mol
c) –184.4 kJ/mol
d) –226.7 kJ/mol
e) –498.8 kJ/mol

27. When 1.50 g of NaOH (molar mass = 40.00 g/mol) is added to 50.0 g of water at 25.00°C in a calorimeter, the temperature of the water increases to 32.75°C. Assuming that the specific heat of the solution is 4.18 J/g·°C, calculate ΔH (in kJ/mol) for the reaction:

$$NaOH(s) \rightleftarrows NaOH(aq) \qquad \Delta H = ???$$

a) -44.5 kJ
b) +44.5 kJ
c) -1.67 kJ
d) +1.67 kJ
e) -48.6 kJ

28. Consider the following thermochemical equation:
$2Mg(s) + O_2(g) \rightarrow 2MgO(s) \qquad \Delta H = -1204$ kJ
Calculate the amount of heat transferred when 17.5 g of magnesium reacts at constant pressure.

a) -867 kJ
b) -2107 kJ
c) -1053 kJ
d) -433 kJ
e) -173 kJ

29. Which of the following statements concerning the internal energy of a system, E, are true?

I. It is a state function.
II. It can be measured exactly.
III. $\Delta E = q + w$
IV. When a system undergoes a process in which it gains energy from the surroundings, the ΔE for the process is positive.

a) III and IV
b) I and III
c) I, III, and IV
d) I and II
e) I, II, III, and IV

30. What is the value of ΔE for a system that performs 213 kJ of work on its surroundings and loses 79 kJ of heat?

a) +292 kJ
b) -292 kJ
c) +134 kJ
d) -134 kJ
e) -213 kJ

31. How much heat is required to raise the temperature of 15 g of lead from 22°C to 37°C? (The specific heat of lead is 0.13 J/g·°C.)

a) 2.0 J
b) 0.13 J
c) 5.8×10^{-4} J
d) 29 J
e) 0.13 J

32. A chemical reaction that absorbs heat from the surroundings is said to be _____ and has a _____ value of ΔH at constant pressure.

a) endothermic, positive
b) endothermic, negative
c) exothermic, positive
d) exothermic, negative
e) exothermic, neutral

Answers

1. e	11. a	21. a	31. d
2. e	12. a	22. e	32. a
3. c	13. c	23. d	
4. a	14. a	24. d	
5. b	15. d	25. c	
6. b	16. d	26. a	
7. d	17. c	27. a	
8. b	18. a	28. d	
9. d	19. a	29. c	
10. c	20. d	30. b	