Chapter 5 – Chapter 8 Practice Problems

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1. Assign the oxidation state to each atom in the nitrate ion (NO_3^-).

   A. N = +3, O = -2
   B. N = +5, O = -2
   C. N = -3, O = +2
   D. N = +6, O = -2

2. Consider the following chemical equations:

   i. $Pb(NO_3)_2\ (aq) + 2KI\ (aq) \rightarrow PbI_2\ (s) + 2KNO_3\ (aq)$
   ii. $CH_4\ (g) + 2O_2\ (g) \rightarrow CO_2\ (g) + 2H_2O\ (g)$
   iii. $H_2SO_4(aq) + 2KOH\ (aq) \rightarrow K_2SO_4\ (aq) + 2H_2O(l)$

   Which reaction is a redox reaction, and which substances act as the reducing agent and oxidizing agent?

   A. Reaction 1 is redox, KI is the reducing agent and $Pb(NO_3)_2$ is the oxidizing agent.
   B. Reaction 2 is redox, O_2 is the reducing agent and CH_4 is the oxidizing agent.
   C. Reaction 2 is redox, CH_4 is the reducing agent and O_2 is the oxidizing agent.
   D. Reaction 3 is redox, KOH is the reducing agent and H_2SO_4 is the oxidizing agent.

3. Use the provided excerpt of the Activity Series of Metals (listed from most active/easiest to oxidize to least active) to determine whether reactions (a) and (b) are spontaneous

   Most Active Least Active

   $$K > Ca > Na > Mg > Al > Zn > Fe > Ni > Pb > H_2 > Cu > Ag$$

i. $Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu\ (s)$
ii. $Fe\ (s) + Mg^{2+}(aq) \rightarrow Fe^{2+}(aq) + Mg(s)$

A. (i) is spontaneous and (ii) is nonspontaneous
B. (i) is nonspontaneous and (ii) is spontaneous
C. Both (i) and (ii) are spontaneous
D. Both (i) and (ii) are nonspontaneous

4. A fixed amount of an ideal gas initially has a pressure of P_1.

   First, the absolute temperature of the gas (in kelvins) is doubled while the volume is kept constant. Next, the volume of the gas is halved while the temperature is kept constant.

   What is the final pressure of the gas (P_2)relative to its initial pressure (P_1)?

   A. $\frac{1}{4}P_1$
   B. Equal to the initial pressure (P_1)
   C. $2P_1$
   D. $4P_1$

5. A 12.0-L compressed gas cylinder contains 0.785 mol of helium at a temperature of 298 K. What is the pressure (in atm and psi) of the gas in the cylinder?

   (Use R = 0.08206 L • atm / (mol • K) and 1 atm = 14.7 psi)

   A. 0.625 atm or 9.19 psi
   B. 1.60 atm or 23.5 psi
   C. 6.25 atm or 91.9 psi
   D. 24.1 atm or 354 psi

6. A deep-sea diver breathes a gas mixture containing oxygen and helium with an oxygen mole fraction of 0.040. What must the total pressure be for the partial pressure of oxygen to be 0.20 atm?

   A. 0.0080 atm
   B. 0.24 atm
   C. 5.0 atm

D. 8.0 atm

7. Ammonia can be synthesized by the reaction:

$N_2\ (g) + 3H_2\ (g) \rightarrow 2NH_3\ (g)$

What volume (in liters) of hydrogen gas, measured at a temperature of 315 K and a pressure of 745 mmHg

(Molar mass of NH_3 = 17.03 g/mol; R = 0.08206 L • atm / (mol • K); 1 atm = 760 mmHg)

A. 19.7 L
B. 39.5 L
C. 59.2 L
D. 88.8 L

8. How does the behavior of a real gas compare to an ideal gas at moderate pressure versus very high pressure?

A. At moderate pressure, intermolecular forces pull particles together so the molar volume is smaller than ideal; at very high pressure, the physical size of the molecules takes up space, so the molar volume is larger than ideal.
B. At moderate pressure, molecular size dominates so the molar volume is larger than ideal; at very high pressure, intermolecular forces dominate so the molar volume is smaller than ideal.
C) At both moderate and very high pressures, intermolecular forces always keep the molar volume smaller than ideal.
D) At both moderate and very high pressures, the physical size of the particles always keeps the molar volume larger than ideal.

9. A sample of food releases 250 cal of heat energy upon combustion. How many joules (J) is this equivalent to?

(Use 1 cal = 4.184 J)

A. 59.8 J
B. 598 J
C. 1046 J

D. 2500 J

10. A system absorbs 350 J of heat from its surroundings while doing 150 J of work on the surroundings. What is the change in the internal energy (ΔE) of the system?

    A. +500 J
    B. + 200 J
    C. -200 J
    D. - 500 J

11. A silver ring with a mass of 5.50 g is dropped in the snow. How much heat is absorbed by the ring as it warms from the temperature of the snow, -12.0 °C, to body temperature, 37.0 °C? (The specific heat capacity of silver is 0.235 J/(g ∗ °C)

    A. 32.3 J
    B. 63.3 J
    C. 47.8 J
    D. 270 J

12. A gas cylinder with a movable piston expands from an initial volume of 0.250 L to a final volume of 1.45 L against a constant external pressure of 1.20 atm. How much pressure-volume work (in joules) is done by the gas?

    (Use 1 L • atm = 101.3 J)

    A. -1.44 J
    B. -122 J
    C. -146 J
    D. +146 J

13. When 1.010 g of sucrose ($C_{12}H_{22}O_{11}$) undergoes combustion in a bomb calorimeter, the temperature rises from 24.92 °C to 28.33 °C. Find (ΔE_{rxn}) for the combustion reaction in kJ/mol sucrose. The heat capacity of the bomb calorimeter (C_{cal}), determined in a separate experiment, is 4.90 kJ/°C.

    (Molar mass of sucrose = 342.3 g/mol)

    A. -16.7 kJ/mol

B. +5.66 x 10^3 kJ/mol
C. -5.66 x 10^3 kJ/mol
D. -1.97 x 10^4 kJ/mol

14. An exothermic chemical reaction occurs in an open beaker of water. What happens to the temperature of the water?

A. The temperature falls.
B. The temperature rises.
C. The temperature remains unchanged.
D. Not enough information.

15. Nitric oxide reacts with oxygen according to the equation:

$$2\ NO(g)\ +\ O_2(g) -> \ 2\ NO_2(g)\ \Delta H_{rxn} = \ -114.4\ kJ$$

Calculate the heat (in kJ) associated with the complete reaction of 85.0 g of NO. (Molar mass of NO = 30.01 g/mol)

A. -162 kJ
B. -324 kJ
C. -648 kJ
D. -9.72 x 10^3 kJ

16. Methane combusts in oxygen according to the balanced reaction:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O\ (l)$$

Use the following standard enthalpies of formation (Δ_f°)

$$\Delta_f^\circ\ CH_4 = \ -74.8\frac{kJ}{mol}$$
$$\Delta_f^\circ\ CO_2 = \ -393.5\frac{kJ}{mol}$$
$$\Delta_f^\circ\ H_2O = \ -285.8\ \frac{kJ}{mol}$$

A. -604.5 kJ
B. -890.3 kJ

C. -965.1 kJ
D. $+890.3$ kJ

17. Find ΔH_{rxn} for the formation of ethylene:

$$2\ C(s)\ +\ 2\ H_2(g) \rightarrow\ C_2H_4(g)$$

Use these reactions with known Delta H values:

$$(1) C_2H_4(g) +\ 3\ O_2(g) \rightarrow\ 2\ CO_2(g) +\ 2\ H_2O(l)\ \Delta H =\ -1411\ kJ$$
$$(2)\ C(s)\ +\ O_2(g) \rightarrow\ CO_2(g) \qquad \Delta H\ =\ -393.5\ kJ$$
$$(3)\ 2\ H_2(g)\ +\ O_2(g) \rightarrow\ 2H_2O(l) \qquad \Delta H\ =\ -571.6\ kJ$$

A. +1411 kJ
B. -1411 kJ
C. +52.4 kJ
D. -52.4 kJ

18. Light wave X has a higher frequency and a smaller amplitude than light wave Y. Which statement correctly compares the two waves?

A. Light wave X is dimmer and has a shorter wavelength than light wave Y.
B. Light wave X is brighter and has a longer wavelength than light wave Y.
C. Light wave X is dimmer and has a longer wavelength than light wave Y.
D. Light wave X is brighter and has a shorter wavelength than light wave Y.

19. A pulsed laser emits light with a wavelength of 450 nm. In a single pulse, the laser delivers a total of 0.250 J of energy. How many joules of energy does a single photon possess, and how many photons are in that single pulse?

(Planck's constant h = 6.626 x 10^-34 J*s; speed of light c = 3.00 x 10^8 m/s)

A. 4.42 x 10^-19 J per photon; 5.66 x 10^17 photons
B. 2.98 x 10^-19 J per photon; 8.39 x 10^17 photons
C. 4.42 x 10^-28 J per photon; 5.66 x 10^26 photons
D. 1.47 x 10^-19 J per photon; 1.70 x 10^18 photons

20. Calculate the de Broglie wavelength of an electron traveling at a velocity of 3.40 x 10^6 m/s.

(Planck's constant h = 6.626 x 10^-34 kg*m^2/s; mass of an electron m = 9.11 x 10^-31 kg)

A. 2.14 x 10^-10 m
B. 4.67 x 10^-10 m
C. 1.25 x 10^-9 m
D. 2.14 x 10^-13 m

21. According to Heisenberg's uncertainty principle, what happens to our knowledge of an electron's velocity as our measurement of its position becomes more precise?

A. The velocity becomes more precisely known.
B. The uncertainty in velocity increases, so the velocity becomes less precisely known.
C. The velocity drops to zero.
D. The uncertainty in velocity remains unchanged.

22. Which of the following sets of quantum numbers (n, l, ml) is NOT allowed?
A. n = 4, l = 2, ml = -1
B. n = 3, l = 1, ml = 0
C. n = 2, l = 2, ml = +1
D. n = 5, l = 0, ml = 0

23. Determine the wavelength of the light absorbed when an electron in a hydrogen atom makes a transition from an orbital in the n = 2 level to an orbital in the n = 6 level.

A. 410 nm
B. 434 nm
C. 486 nm
D. 656 nm

24. Which statement correctly describes the geometric shape and spatial orientation of atomic orbitals based on their angular momentum quantum number (l)?

A. An s orbital (l = 0) is dumbbell-shaped with one nodal plane passing through the nucleus

B. A p orbital (l = 1) is spherical, and its electron density increases uniformly in all directions away from the nucleus

C. A d orbital (l = 2) typically has a four-lobed (cloverleaf) shape, with orientations defined by two nodal planes or surfaces.

D. A f orbital (l = 3) consists of two perpendicular dumbbells with no nodal surfaces.

ANSWER KEY

1. B
2. C
3. A
4. D
5. B
6. C
7. C
8. A
9. C
10. B
11. B
12. C
13. C
14. B
15. A
16. B
17. C
18. A
19. A
20. A
21. B

22. C

23. A

24. C