1. A solution of sodium carbonate is treated with a solution of nitric acid. Bubbles are observed in the colorless solution. The balanced equation is

   a. $Na_2CO_3(aq) + 2HNO_3(aq) \rightarrow H_2O(l) + CO_2(g) + 2NaNO_3(aq)$

   b. $Na_2CO_3(aq) + 2HNO_3(aq) \rightarrow H_2CO_3(aq) + 2NaNO_4(aq)$

   c. $Na_2CO_3(aq) + 2HNO_3(aq) \rightarrow H_2(g) + CO_2(g) + 3\ O_2(g) + N_2(g) + Na_2O(aq)$

   d. $2Na_2CO_3(aq) + 2HNO_3(aq) \rightarrow H_2O(l) + 2CO(g) + 3\ O_2(g) + NaNO_3(aq)$

   e. $2Na_2CO_3(aq) + 2HNO_3(aq) \rightarrow H_2O(l) + 2CO_2(g) + N_2(g) + 2NaNO_3(aq)$

2. When an aqueous solution of lead(II) nitrate is treated with an aqueous solution of potassium carbonate, one may observe

   a. the formation of a precipitate, $PbCO_3$.

   b. the formation of a gas, $CO_2$.

   c. both the formation of $PbCO_3$ precipitate and $CO_2$ gas.

   d. the formation of two precipitates, $KNO_3$ and $PbCO_3$.

   e. no reaction.

3. The oxidation number of chromium in $Na_2CrO_4$ is

   a. -2.

   b. +2.

   c. +6.

   d. -6.

   e. +8.

4. What volume of 0.150 M NaOH is needed to react completely with 3.45 g iodine according to the equation:

   $3\ I_2 + 6NaOH \rightarrow 5NaI + NaIO_3 + 3H_2O$?

   a. 1.02 mL

   b. 2.04 mL

   c. 4.08 mL

   d. 45.3 mL

   e. 181 mL

5. What is the **total** concentration of ions in a 0.0360 M solution of $Na_2CO_3$?

   a. 0.0120 M
   b. 0.0720 M
   c. 0.0900 M
   d. 0.108 M
   e. 0.144 M

6. A solution of nitric acid contains which of the following ions in easily measurable quantities?

   a. $H^+$, $N_2^-$, $O_2^-$
   b. $H^+$, $NO_2^-$
   c. $H_2^+$, $NO_3^-$
   d. $H_2^+$, $2NO_2^-$
   e. $H^+$, $NO_3^-$

7. How many joules are equivalent to 37.7 cal?

   a. 9.01 J
   b. 9.43 J
   c. 1.51 J
   d. 4.184 J
   e. 158 J

8. When 15.0 grams of an alloy is heated from 20.0 ºC to 40.0 ºC it absorbs 727 joules of energy. The specific heat of the alloy is

   a. 2.42 J/g·K
   b. 0.218 J/g·K
   c. -2.42 J/g·K
   d. -0.218 J/g·K
   e. 0.206 J/g·K

9. When 325 grams of water at 21.0 ºC is mixed with an unknown mass of water at a temperature of 45.0 ºC, the final temperature of the resulting mixture is 36.0 ºC. What was the mass of the second sample of water?

   a. 7.24 g
   b. 226 g
   c. 542 g
   d. 874 g
   e. 2266 g

10. What is ΔE for a system which has the following two steps:

Step 1: The system absorbs 70 J of heat while 40 J of work are performed on it.
Step 2: The system releases 40 J of heat while doing 70 J of work.

   a. 110 J
   b. 100 J
   c. 90 J
   d. 30 J
   e. zero

11. If 15.0 g water at 28.0 ºC is added to 125.0 g water at 20.0 ºC, what is the final temperature of the resulting mixture?

   a. 20.9 ºC
   b. 22.6 ºC
   c. 23.1 ºC
   d. 24.0 ºC
   e. 27.3 ºC

12. Which of the following produces radiation of the highest frequency?

   a. x-rays
   b. AM radio
   c. FM radio
   d. microwave oven
   e. radar

13. Calculate the enthalpy of reaction for the process

$$D + F \longrightarrow G + M$$

using the following equations and data:

$$G + C \longrightarrow A + B \qquad \Delta H^\circ = +277 \text{ kJ}$$
$$C + F \longrightarrow A \qquad \Delta H^\circ = +303 \text{ kJ}$$
$$D \longrightarrow B + M \qquad \Delta H^\circ = -158 \text{ kJ}$$

a. -132 kJ
b. +422 kJ
c. +132 kJ
d. -184 kJ
e. -422 kJ

14. Calculate the enthalpy of reaction for the process

$$6\ C(s) + 3\ H_2(g) \longrightarrow C_6H_6(l) \qquad \Delta H^\circ = ?$$

using the following equations and data:

$$2\ C_6H_6 + 15\ O_2 \longrightarrow 12\ CO_2(g) + 6\ H_2O(l) \qquad \Delta H^\circ = -6534.8 \text{ kJ}$$
$$C(s) + O_2(g) \longrightarrow CO_2(g) \qquad \Delta H^\circ = -393.5 \text{ kJ}$$
$$H_2 + \tfrac{1}{2}\ O_2 \longrightarrow H_2O(l) \qquad \Delta H^\circ = -285.8 \text{ kJ}$$

a. +49.0 kJ
b. –49.0 kJ
c. +98 kJ
d. -98 kJ
e. -7214.1 kJ

15. Planck suggested that all energy gained or lost by an atom must be some integral multiple of a minimum amount of energy called a(n)

a. electron.
b. spectrum.
c. magnetic moment.
d. quantum.
e. orbital.

16. What type of orbital is designated n = 3, $l$ = 2, $m_l$ = 0?

a. 2s

b. 3s

c. 3p

d. 3d

e. 4d

17. Which of the following electronic transitions in a hydrogen atom would have the longest wavelength?

a. n = 4 to n = 1

b. n = 4 to n = 2

c. n = 2 to n = 1

d. n = 4 to n = 3

e. n = 1 to n = 0

18. What is the energy (in J) of one mole of photons of green light ($\lambda$ = 500 nm). (c = 2.998 x $10^{8}$ m/s, h = 6.626 x $10^{-34}$ Js)

a. 5.90 x $10^{8}$ J/mol

b. 5.90 x $10^{-8}$ J/mol

c. 2.39 x $10^{7}$ J/mol

d. 2.39 x $10^{5}$ J/mol

e. 2.39 x $10^{5}$ kJ/mol

19. In the photoelectric effect, no electrons are emitted from the surface of a silver foil when the frequency of the incident light is less than 1.15 x $10^{15}$ Hz. At frequencies > 1.15 x $10^{15}$ Hz electrons were emitted. What is the minimum energy necessary to eject an electron from the silver? (1 Hz = 1 cycle/second = 1 $s^{-1}$, h = 6.626 x $10^{-34}$ Js)

a. 6.63 x $10^{-34}$ J

b. 1.26 x $10^{-22}$ J

c. 7.62 x $10^{-19}$ J

d. 3.44 x $10^{25}$ J

e. 1.74 x $10^{34}$ J

20. How much thermal energy is required to heat 500 g of ice to steam at 200 ºC? Use the following values to calculate:

| State | specific heat capacity [J/g·K] |
|---|---|
| ice | 2.1 |
| water | 4.2 |
| steam | 2.0 |

Heat of fusion of water = 333.5 J/g
Heat of vaporization of water = 2256 J/g

a. 429 kJ

b. 1347 kJ

c. 1391 kJ

d. 1505 kJ

e. 1557 kJ