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

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, $PbCO_3$.

3. The oxidation number of chromium in Na_2CrO_4 is

   c. +6.

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

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

   e. 181 mL

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

   d. 0.108 M

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

   e. H^+, NO_3^-

7. How many joules are equivalent to 37.7 cal?

   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

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?

   c. 542 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.

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

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

a. x-rays

13. Calculate the enthalpy of reaction for the process

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

using the following equations and data:

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

a. -132 kJ

14. Calculate the enthalpy of reaction for the process

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

using the following equations and data:

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

a. +49.0 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)

d. quantum.

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

d. 3d

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

d. n = 4 to n = 3

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

d. 2.39×10^{5} J/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 1.15×10^{15} Hz. At frequencies > 1.15×10^{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}, $h = 6.626 \times 10^{-34}$ Js)

c. 7.62×10^{-19} 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

None of the solution choices offered was correct. Therefore, all students receive credit for this question. Those students who calculated the correct value (1605 kJ) received extra credit.