**Instructions:** On your scantron sheet enter your name, UF ID number, and Form Code (start with the first space and leave the last space blank). This exam consists of 20 multiple choice questions each worth 10.0 points for a total maximum of 200 pts. Keep your exam sheet (mark your answers on it and on the scantron sheet). Turn in only the scantron. *Any bubbling error will count as an incorrect response, including wrong form code and answers.*
(Useful Information: 101.3 J = 1 atm·L; 1 cal = 4.184 J; 1 Cal = 1000 cal; $C_{Water}$ = 4.184 J/g·C)

1. If a system gains 50 kJ of energy during a process, what is the change in energy for the surroundings ($\Delta E_{surr}$)? Is this process endo- or exothermic for the system?

   (1) +50 kJ; endothermic (2) -50 kJ; endothermic (3) +50 kJ; exothermic
   (4) -50 kJ; exothermic (5) Not enough information

2. How much work (in J) is required to expand the volume of a pump from 1.0 L to 4.5 L against an external pressure of 1.1 atm?

   (1) -3.85 J (2) -3.9 J (3) -3.9 kJ (4) -390. J (5) -390.1 J

3. Determine the mass of water produced by burning enough methane to produce 250.0 kJ of heat.
   ($\Delta H_{comb}$ = -802.3 kJ/mol)

   (1) 5.61 g (2) 11.23 g (3) 9.32 g (4) 4.66 g (5) 57.8 g

4. Three 1-kg room temperature samples of lead ($C_{Pb}$ = 0.130 J/g·K), aluminum ($C_{Al}$ = 0.900 J/g·K), and ethanol ($C_{EtOH}$ = 2.44 J/g·K) are placed in a heating furnace. After 30 minutes, order these samples by increasing temperature.

   (1) Lead < Aluminum < Ethanol (2) Ethanol < Lead < Aluminum (3) Ethanol < Aluminum < Lead
   (4) Aluminum < Ethanol < Lead (5) They are all the same temperature

5. Calculate $\Delta H_{rxn}$ for the combustion of methane. Use the following reactions and given changes in enthalpies.

   $H_2O(l) \rightarrow H_2O(g)$ $\Delta H$ = 44.0 kJ
   $CH_2O(g) + H_2O(g) \rightarrow CH_4(g) + O_2(g)$ $\Delta H$ = 284.0 kJ
   $CH_2O(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$ $\Delta H$ = -527.0 kJ

   (1) -855 kJ (2) -767 kJ (3) -899 kJ (4) +287 kJ (5) -726 kJ

6. One tablespoon of mayonnaise has a mass of 25.0 g. It is combusted in a bomb calorimeter whose heat capacity is 87.0 kJ/°C. The temperature of the calorimeter rose from 22.0 °C to 27.3 °C. What is the food caloric content of the mayonnaise?

   (1) 461 Cal/g (2) 18.4 Cal/g (3) 77.2 Cal/g (4) 7.72 x $10^4$ Cal/g (5) 4.41 Cal/g

7. How much heat is required to warm 2.00 liters of water from 25.0 °C to 95.0 °C?
   (Assume a density of 1.00 g/mL for water)

   (1) 5.86 x $10^5$ kJ (2) 1.40 x $10^2$ kJ (3) 3.35 x $10^1$ kJ (4) 5.86 x $10^2$ kJ (5) -1.40 x $10^2$ kJ

8. A system absorbs 317 kJ of heat and the surroundings do 284 kJ of work on the system. What is the change in internal energy of the system?

   (1) 33 kJ (2) -601 kJ (3) -33 kJ (4) 601 kJ (5) Not enough information

9. The explosive nitroglycerin ($C_3H_5N_3O_9$) decomposes rapidly upon ignition according to the following equation:
   $4\ C_3H_5N_3O_9(l) \rightarrow 12\ CO_2(g) + 10\ H_2O(g) + 6\ N_2(g) + O_2(g)$ $\Delta H_{rxn}$ = -5678 kJ
   Calculate the standard enthalpy of formation ($\Delta H_f$) for nitroglycerin. For $CO_2(g)$, $\Delta H_{rxn}$ = -393.5 kJ/mol. For $H_2O(g)$, $\Delta H_{rxn}$ = -241.82 kJ/mol.

   (1) 12818 kJ/mol (2) -1462 kJ/mol (3) 5043 kJ/mol (4) -366 kJ/mol (5) 5526 kJ/mol

10. Suppose that 5.00 g of silver is initially at 27.0 °C. What is the final temperature of the sample of silver after it has released 0.75 kJ of heat? ($C_{Ag}$ = 0.235 J/g·K)

    (1) 938 K (2) 665 K (3) 27.6 K (4) 301 K (5) 336 K

11. What is the correct equation for the formation of methanol ($CH_3OH$) from its elements in their standard states?

    (1) $2\ C(s) + 4\ H_2(g) + O_2(g) \rightarrow 2\ CH_3OH(l)$
    (2) $C(s) + 2\ H_2(g) + ½\ O_2(g) \rightarrow CH_3OH(l)$
    (3) $C(s) + H_2O(l) \rightarrow CH_3OH(l)$
    (4) $C(s) + 2\ H_2O(g) \rightarrow CH_3OH(l)$
    (5) $CH_4(g) + ½\ O_2(g) \rightarrow CH_3OH(l)$

12. Under certain nonstandard conditions, oxidation by $O_2(g)$ of 1 mol of $SO_2(g)$ to $SO_3(g)$ absorbs 89.4 kJ. The heat of formation of $SO_3(g)$ is -204.1 kJ/mol under these conditions. Determine the heat of formation of $SO_2(g)$.

(1) 293.5 kJ/mol (2) -293.5 kJ/mol (3) 497.6 kJ/mol (4) -497.6 kJ/mol (5) 0 kJ/mol

13. Which of the following are state functions?
I. $q$ II. $w$ III. $\Delta E$ IV. Temperature

(1) None of the above
(2) I and II only
(3) I, III, and IV only
(4) III and IV only
(5) All of the above

14. In a coffee-cup calorimeter, 1.25 g of $NH_4NO_3$ is dissolved in enough water to make 25.0 mL of solution. The initial temperature is 25.8 $^oC$ and the final temperature is 21.9 $^oC$. Calculate the change in enthalpy for the reaction in kJ/mol. (Assuming 1.0 g/mL as the density of the solution).

(1) 326.35 kJ/mol (2) 26.1 kJ/mol (3) -407.94 kJ/mol (4) -26.1 kJ/mol (5) 407.94 kJ/mol

15. What mass of propane ($C_3H_8$) must be burned (i.e. combusted) to emit 576 kJ of heat? ($\Delta H_{comb}$ = -2217 kJ/mol)

(1) 11.5 g (2) 0.260 g (3) 3.85 g (4) 0.0876 g (5) 169 g

16. What volume (in mL) of 0.750 M NaOH is required to titrate 100.00 mL of 1.00 M $H_2SO_4$ to the equivalence point?

(1) 37.5 mL (2) 75.0 mL (3) 133 mL (4) 188 mL (5) 267 mL

17. What is the name for the compound $RuO_2$.

(1) Rhodium dioxide (2) Ruthenium(IV) oxide (3) Ruthenium dioxide
(4) Ruthenium (II) oxide (5) Ruthenium oxide

18. What volume of a 15.0 M $HNO_3$ solution is required to completely react with 35.7 mL of a 10.8 M $Na_2CO_3$solution according to the following balanced chemical equation?

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

(1) 38.6 mL (2) 25.7 mL (3) 77.1 mL (4) 71.4 mL (5) 51.4 mL

19. What mass (kg) of $NH_3$ will be formed when 7.22 kg of $H_2$ and 43.5 kg of $N_2$ are added according to the following balanced chemical equation? $3\ H_2(g) + N_2(g) \rightarrow 2\ NH_3(g)$

(1) 122.0 kg (2) 40.67 kg (3) 81.97 kg (4) 52.89 kg (5) 17.63 kg

20. If 3.5 L of a 1.1 M $CaCl_2$ solution is diluted to 500.0 mL, what is the molarity of the diluted solution?

(1) 157.14 M 2) 0.0077 M (3) 1.6 M (4) 7.7 M (5) 0.16 M