CHEM _____ Lab Section Number: _____

Name (printed):_____

Signature:_____

This exam consists of 36 questions all of equal value for a total of 225 points. Make sure that your test has all of the pages. *Please read each problem carefully*. There are no intentionally misleading questions; each problem should be taken at its face value. Please mark your answers ***on the Scantron sheet*** provided to you ***and on the actual exam***.

You will be given a periodic table and an exam information sheet to use during the exam. You may remove it from the exam make it more accessible. You may also use the designated Casio fx-300ms-plus calculator or equivalent non-programmable non-graphing scientific calculator during the exam. Use the back pages of the test as scratch paper. You are not allowed to use any devices capable of accessing the internet, textbooks, notes, or homemade reference sheets during the exam.

You may leave if you finish the exam early. Give the exam and the information sheet to your TA and leave quietly without disturbing other students. Before leaving, check that all your answers have been properly entered on the Scantron sheet and the exam and that your name is written on every page of the exam and on the Scantron sheet.

All cell phones and electronic devices must be turned off and put away. Please remove all hats and caps. Place your books and all papers out of sight under your seat. If the TA believes that you might be looking at your neighbor's paper, you will be asked to move to a new location.

Exam scores will be posted on Blackboard as soon as the grading is complete. Your test will be returned to you in the first lab meeting of next week. If you have any questions regarding the grading of your exam, please notify your TA.

The time available for the exam is 120 minutes. **Good luck!**

Name: _____ Lab Section #: _____

Please mark your answers on the scantron sheet using a #2 pencil and also mark your answers on the exam itself.

Mark Test From "B" on your scantron.

1. FM station KROCK broadcasts music at 99.1 MHz. Find the wavelength of these waves.

   (a) 1.88×10^{-2} m
   (b) 3.03 m
   (c) 3.03 km
   (d) 5.33×10^{-2} m
   (e) $> 10^{3}$ m

2. If the energy of a photon is 1.32×10^{-18} J, what is its wavelength in nm?

   (a) 150. nm
   (b) 1.50×10^{-7} nm
   (c) 1.99×10^{15} nm
   (d) 1.99×10^{24} nm
   (e) 1.50×10^{-16} nm

3. Bohr theory of the hydrogen atom predicts the energy difference (in J) between the $n = 3$ and the $n = 5$ state to be

   (a) -1.64×10^{-18} J
   (b) 1.36×10^{-18} J
   (c) 1.55×10^{-19} J
   (d) 1.64×10^{-18} J
   (e) -1.55×10^{-18} J

4. What type of electromagnetic radiation has a wavelength of 10^{-10} m?

   (a) Infrared (IR)
   (b) Ultraviolet (UV)
   (c) X-ray
   (d) Radio Frequency (RF)
   (e) Visible

5. The shape of an atomic orbital is associated with which

   (a) m_l
   (b) l
   (c) n
   (d) m_s
   (e) υ

6. Which of the following is a correct set of quantum numbers for a 5f orbital?

   (a) $n = 5$, $l = 2$, $m_l = +3$
   (b) $n = 5$, $l = 4$, $m_l = +3$
   (c) $n = 3$, $l = 3$, $m_l = +3$
   (d) $n = 4$, $l = 3$, $m_l = +2$
   (e) $n = 5$, $l = 3$, $m_l = +1$

7. A sprinter must average 24.0 mi/h to win a 100-m dash in 9.30 s. What is his wavelength at this speed if his mass is 84,500 g?

   (a) 3.26×10^{-37} m
   (b) 3.96×10^{-31} m
   (c) 5.08×10^{-30} m
   (d) 1.34×10^{-30} m
   (e) 7.29×10^{-37} m

8. What is the correct order of decreasing size of the following ions?

   (a) $P^{3-} > Cl^- > K^+ > Ca^{2+}$
   (b) $Ca^{2+} > K^+ > Cl^- > P^{3-}$
   (c) $K^+ > Cl^- > Ca^{2+} > P^{3-}$
   (d) $K^+ > Cl^- > P^{3-} > Ca^{2+}$
   (e) None of the above is correct.

9. Based on position in the periodic table, predict which has the <u>smallest</u> atomic radius?

   (a) I
   (b) F
   (c) N
   (d) Rb
   (e) Li

10. In a single atom, what is the maximum number of electrons which can have quantum number $n = 4$?

    (a) 4
    (b) 6
    (c) 18
    (d) 32
    (e) 36

11. Select the correct electron configuration for Cu.

    (a) $[Ar]5s^24d^9$
    (b) $[Ar]4s^24d^9$
    (c) $[Ar]4s^24p^63d^3$
    (d) $[Ar]4s^23d^9$
    (e) $[Ar]4s^13d^{10}$

12. Which one of the following equations correctly represents the process involved in the electron affinity of X?

(a) $X(g) \rightarrow X^+(g) + e^-$

(b) $X(g) + e^- \rightarrow X^-(g)$

(c) $X^+(g) + Y^-(g) \rightarrow XY(s)$

(d) $X^+(g) \rightarrow X^+(aq)$

(e) $X^+(g) + e^- \rightarrow X(g)$

13. Which one of the following is the <u>most</u> polar covalent bond?

(a) B-F
(b) C-F
(c) N-F
(d) O-F
(e) None of the above is correct.

14. Which one of the following elements is the <u>least</u> electronegative?

(a) F
(b) Fr
(c) Br
(d) C
(e) Pt

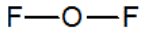
15. Which one of the following bonds has the <u>most</u> ionic character?

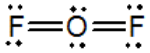
(a) C-F
(b) C-O
(c) C-C
(d) C-B
(e) C-N

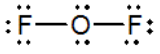
16. Select the correct formula for a compound formed from barium and nitrogen.

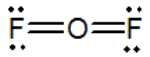
(a) BaN
(b) BaN_2
(c) Ba_2N_3
(d) Ba_2N
(e) Ba_3N_2

17. Select the correct Lewis structure for OF_2.

(a) 

(b) 

(c) 

(d) 

(e) None of the above are correct

18. Which of the following molecules has an electron deficient Lewis dot structure?

(a) CH_4
(b) BH_3
(c) O_2
(d) NH_3
(e) CO_2

19. The difference between kinetic and potential energy is that

(a) kinetic energy refers to energy stored within a substance and potential energy refers to the possibility that a substance might release its energy
(b) kinetic energy refers to motion and potential energy refers to energy stored within a substance
(c) kinetic energy refers the reaction of a substance experiencing a physical force and potential energy refers to the possibility that a substance might release its energy
(d) kinetic energy refers the a change in the electron configuration of a substance and potential energy relates to the original electron configuration
(e) kinetic energy and potential energy represent two extremes: a substance has potential energy at low temperature and kinetic energy at high temperature

20. If a system undergoes an adiabatic change (i.e., $q = 0$) and its energy increases ($\Delta E > 0$), then what work was done?
(a) No work was done.
(b) Work was done on the system by its surroundings.
(c) Work was done on the surroundings by the system.
(d) The system and the surroundings did a matching amount of work on one another.
(e) The total work of the system and surroundings approaches infinity.

21. Which of the following defines the principle of conservation of energy?
(a) Physical and chemical systems minimize work to conserve energy.
(b) Chemical reactions conserve energy by absorbing heat from their surroundings.
(c) Energy is never created or destroyed; it is transferred from one form to another.
(d) The total energy of the universe gradually approaches zero.
(e) $\Delta U = q + w$

22. If 0.96 kJ of energy is needed to raise the temperature of 1.0×10^2 g of lead from 25 °C to 100 °C, then what is the specific heat capacity of lead?

    (a) C = 72 kcal·mol^{-1}
    (b) C = 12.8 J·K^{-1}
    (c) c = 7.8 J·g^{-1}·K^{-1}
    (d) c = 0.13 J·g^{-1}·K^{-1}
    (e) c = 0.00013 J·g^{-1}·K^{-1}

23. In an ideal calorimeter, you combine 0.200 mol KOH(aq) with 0.200 mol HNO_3(aq) in a total of 1.00×10^2 mL water. The temperature increases from 22.4 °C to 49.2 °C. What is the heat change of this reaction in kJ *per mole of base*? Assume that density of the mixture is 0.997 g / mL and its specific heat capacity is 4.18 J·g^{-1}·K^{-1}, the same as water.

    (a) –11.2 kJ / mol
    (b) 11.2 kJ / mol
    (c) –56.0 kJ / mol
    (d) 56 kJ / mol
    (e) 56000 kJ / mol

24. Combustion of hydrogen gas is described by the following equation.

    $$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l) \qquad \Delta H^\circ_c = -285 \text{ kJ}$$

    Electrolysis is the reverse reaction: splitting water to form hydrogen and oxygen gas. How much energy is needed to produce 2 moles of H_2 by electrolysis?

    (a) 570 kJ
    (b) –570 kJ
    (c) 285 kJ
    (d) –285 kJ
    (e) –143 kJ

25. You have a new, imperfect calorimeter that participates in heat transfer. To measure the heat capacity of this calorimeter, you fill the calorimeter with 5.00×10^2 g of water (c = 4.18 J·g^{-1}·K^{-1}), combust 3.00 g of ethanol (C_2H_6O) in the calorimeter and record that the water's temperature increases from 22.0 °C to 59.6 °C as a result of the heat released by combustion. Given that the heat of combustion of ethanol is known to be –1360 kJ/mol, what is the heat capacity of your new calorimeter? (Ignore the fact that combustion produces a small amount of additional water.)

    (a) 187 J·K^{-1}
    (b) 202 J·K^{-1}
    (c) 228 J·K^{-1}
    (d) 265 J·K^{-1}
    (e) 313 J·K^{-1}

26. What is the difference between ΔH and $\Delta H°$?

    (a) $\Delta H°$ is the temperature-dependent enthalpy change.
    (b) $\Delta H°$ is the reference enthalpy change for a comparison reaction and ΔH is the enthalpy change of your reaction.
    (c) ΔH is the reference enthalpy change for a comparison reaction and $\Delta H°$ is the enthalpy change of your reaction.
    (d) $\Delta H°$ is the enthalpy change under the specific conditions of your reaction and ΔH is the enthalpy change at the standard state: 1 mol/L concentration, 1 ATM pressure, and typically 298.15 K.
    (e) ΔH is the enthalpy change under the specific conditions of your reaction and $\Delta H°$ is the enthalpy change at the standard state: 1 mol/L concentration, 1 ATM pressure, and typically 298.15 K.

27. If you combine 50.0 mL of ethylene glycol (c = 2.20 $J \cdot g^{-1} \cdot K^{-1}$; density = 1.1132 g/mL; the main component of engine antifreeze) at 10.0 °C with 50.0 mL of water (c = 4.18 $J \cdot g^{-1} \cdot K^{-1}$; density = 0.997 g/mL) at 20.0 °C, then what would be the final temperature of the mixture?

    (a) 15.0 °C
    (b) 16.3 °C
    (c) 13.8 °C
    (d) 15.9 °C
    (e) 17.1 °C

28. You are going on an ultralight backpacking trip and bringing along an isobutane-burning camp stove. Assuming that your stove can heat water with perfect efficiency (i.e. no heat is transferred to anything other than the water [obviously, no real stove can do this]), what is the maximum amount of water that you can heat from an outdoor evening temperature of 10 °C (50 °F) to boiling (100 °C) using a standard 4.00 oz. isobutane canister? (4.00 oz. = 113 g; isobutane = C_4H_{10}; $\Delta H°_c$ = –2870 kJ/mol; c_{water} = 4.18 $J \cdot g^{-1} \cdot K^{-1}$; d_{water} = 0.997 g / mL)

    (a) 12.1 L
    (b) 14.4 L
    (c) 14.9 L
    (d) 15.9 L
    (e) 17.1 L

29. Which of these equations correctly describes the heat of formation of monosodium glutamate ($C_5H_8NO_4Na$)?

    (a) $C_5H_8(s) + NO_4(g) + Na(s) \rightarrow C_5H_8NO_4Na(s)$
    (b) $5C(diamond) + 8H(g) + N(g) + 4O(g) + Na(s) \rightarrow C_5H_8NO_4Na(s)$
    (c) $5C(graphite) + 4H_2O(l) + \frac{1}{2}N_2(g) + Na(s) \rightarrow C_5H_8NO_4Na(s)$
    (d) $5C(graphite) + 8H(g) + N(g) + 4O(g) + Na(s) \rightarrow C_5H_8NO_4Na(s)$
    (e) $5C(graphite) + 4H_2(g) + \frac{1}{2}N_2(g) + 2O_2(g) + Na(s) \rightarrow C_5H_8NO_4Na(s)$

30. Calculate $\Delta H°$ for the following reaction using the tabulated standard heats of formation.

$$2NaOH(aq) + H_2CO_3(aq) \rightarrow 2H_2O(l) + Na_2CO_3(aq)$$

substance	$\Delta H°_f$
NaOH	–285 kJ/mol
$H_2CO_3(aq)$	–699 kJ/mol
$H_2O(l)$	–425 kJ/mol
$Na_2CO_3(aq)$	–1131 kJ/mol

(a) 712 kJ/mol
(b) –712 kJ/mol
(c) 572 kJ/mol
(d) –572 kJ/mol
(e) –2540 kJ/mol

31. Under what situation will $\Delta H°_f$ be a positive number?

(a) Never; $\Delta H°_f$ is always a negative number.
(b) When the substance is more stable than its constituent elements in their standard states.
(c) When the substance is less stable than its constituent elements in their standard states.
(d) When the heat of formation involves a phase change from solid elements to a substance in the gas phase.
(e) When there is a pressure increase during the formation of the substance.

32. Given the following chemical equations and enthalpy changes, calculated $\Delta H°$ for the decomposition of sulfuric acid.

$$H_2SO_4(l) \rightarrow SO_3(g) + H_2O(g) \qquad \Delta H° = ?$$

$$H_2S(g) + 2O_2(g) \rightarrow H_2SO_4(l) \qquad \Delta H° = -235.5 \text{ kJ}$$
$$H_2S(g) + 2O_2(g) \rightarrow SO_3(g) + H_2O(l) \qquad \Delta H° = -207 \text{ kJ}$$
$$H_2O(l) \rightarrow H_2O(g) \qquad \Delta H° = 44 \text{ kJ}$$

(a) 72 kJ
(b) –72 kJ
(c) 398 kJ
(d) –398 kJ
(e) 235.5 kJ

33. Using these equations, determine the heat of formation $\Delta H°_f$ of NO(g).

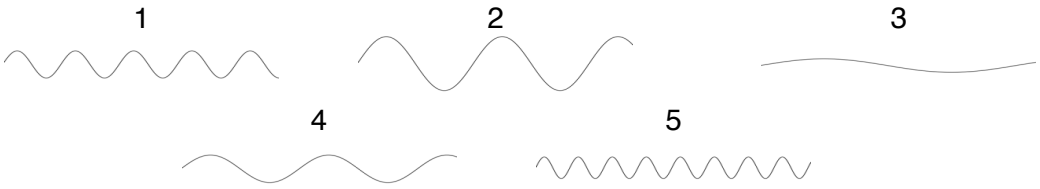
$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$	$\Delta H° = -91.8$ kJ
$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$	$\Delta H° = -906.2$ kJ
$H_2(g) + ½O_2(g) \rightarrow H_2O(g)$	$\Delta H° = -241.8$ kJ

(a) –361 kJ/mol
(b) –183.6 kJ/mol
(c) 90.2 kJ/mol
(d) 361 kJ/mol
(e) 0 kJ/mol

34. Of the symbols below, which is used to express frequency?

(a) ν
(b) λ
(c) *P*
(d) c
(e) C

Below are the graphical representations of five (numbered) waves. Use those images to answer the following two questions.



35. Which of the waves in the figure above has the lowest frequency?

(a) Wave 1
(b) Wave 2
(c) Wave 3
(d) Wave 4
(e) Wave 5

36. Which of the waves in the figure above has the highest energy?

(a) Wave 1
(b) Wave 2
(c) Wave 3
(d) Wave 4
(e) Wave 5