This exam consists of 3 parts on 9 pages (21 Questions)

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NOTE: To receive full credit on problems, you must clearly show all work and your method of determining the answer must be clear. The final answer must be reported to the correct number of significant figures and have the correct units. Questions are written on both sides of each page. The last page contains useful information and a periodic table; the last page should be removed and used for scratch paper and as a reference. Do not put answers on the tear away page.
Please read the following instructions carefully before proceeding! **Part I & II** of your exam will be computer graded. In order for the computer to identify who you are, it is important that you complete the information section properly.

You must use a #2 pencil and completely fill in the appropriate circles on the **RED** computer scan sheet.

1. To help you code the correct circles, first write your last name, first name and middle initial in the boxes (skip a space between each). Then darken the circles that match the letters in the box above it. See the sample to the right.

2. Write the middle nine digits of your ISU identification number in the boxes A-I. Do not skip any spaces. Below each number, darken the circle that matches this number. For example, 123456789. See the sample at bottom right.

3. Write your recitation section number in the special code area, boxes K-L. Do not skip any spaces. For example, if you are in section 8 of Chem 177, write 08. Again, darken the circle that matches the number above it. See the sample at bottom far right.

In Part I & II, select the one best answer for each question. Place your answer on the computer answer sheet by darkening the proper circle for that question. Your computer scan sheet will be your official answer sheet for Part I & II.

All material (exam, answer sheet, scratch paper) must be returned to your TA in order for us to grade your exam.

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Exam #3: Chem 177, Fall 2011
Part I: Multiple Choice: (3 pts each). The answer you fill in on your bubble sheet is the one that will count. You should circle the answer on this sheet for your own reference.

1. Which one of the following is **NOT** a state function?
   a) enthalpy  
   b) work  
   c) temperature  
   d) energy  
   e) volume

2. Which of the following phase change is **exothermic**?
   a) H₂O(s) → H₂O(l)  
   b) H₂O(s) → H₂O(g)  
   c) H₂O(g) → H₂O(l)  
   d) H₂O(l) → H₂O(g)  
   e) None of the above

3. Which one of the following reaction represents the equation for standard enthalpy of formation of lead carbonate, [ΔH°_f (PbCO₃)]?
   a) Pb(s) + C(s) + O₃(g) → PbCO₃(s)  
   b) 2 Pb(s) + 2C(s) + 3 O₂(g) → 2 PbCO₃(s)  
   c) Pb(s) + C(s) + 3/2 O₂(g) → PbCO₃(s)  
   d) Pb(s) + CO(g) + O₂(g) → PbCO₃(s)  
   e) Pb(s) + CO₂(g) + O(g) → PbCO₃(s)

4. Calculate the standard enthalpy of formation of ozone [ΔH°_f (O₃)] from the following information:
   For the reaction, Pb(s) + C(s) + O₃(g) → PbCO₃(s) the enthalpy of reaction (ΔH_rxn) is -841.0 kJ and the standard enthalpy of formation of PbCO₃ is -699.0 kJ/mol.
   a) -142 kJ  
   b) 142 kJ  
   c) 770 kJ  
   d) -1540 kJ  
   e) 0 kJ

5. Which energy level can hold a **maximum** of 18 electrons?
   a) n=1  
   b) n=2  
   c) n=3  
   d) n=4  
   e) none of the above

6. Which of the following electron configuration is **not** possible?
   a) 1s²2s²2p⁵3s¹3p⁴  
   b) 1s²2s²2p⁶3s²3p⁶4s²3d¹⁰  
   c) 1s²2s²2p⁶3s²3p⁴  
   d) 1s²2s²2p⁶3s³3p⁴  
   e) 1s¹2s²2p⁶3s²3p⁴

7. Which element has the following ground state electron configuration shown below?
   1s²2s²2p⁶3s²3p⁶4s²3d¹⁰4p⁶5s¹4d¹⁰
   a) Gold  
   b) Silver  
   c) Cobalt  
   d) Cadmium  
   e) Copper
8. Which of the following is the condensed form of ground state electron configuration for iron, Fe?

a) [Ar]3d^8  b) [Kr]5s^25d^6  c) [Ar]4s^24p^6  d) [Kr]4s^24p^6  e) [Ar]4s^23d^6

9. Correct set of four quantum numbers for the valence (outer most) electron of rubidium, Rb is ________.

a) 5, 0, 0, +1/2  b) 5, 1, 0, +1/2  c) 5, 1, 1, −1/2  d) 6, 0, 0, +1/2  e) 5, 1, 1, +1/2

10. Which one of the following represents an impossible set of quantum numbers for an electron in an atom? (given in the order n, l, m_l, and m_s)

a) 3, 2, −2, 1/2  b) 4, 0, 0, 1/2  c) 3, 3, 3, 1/2  d) 5, 3, 0, −1/2  e) 5, 3, −2, −1/2

11. Which of the following orbital-filling diagram violates Hund’s rule?

a)  

b) 

c) 

d)  

e) 

12. Which electron orbital-filling diagram is correct for a ground state Chromium atom?

a)  

b) 

c) 

d)  

e) 

13. Which one of the following elements will have the smallest ionization energy?

a) lithium  b) sodium  c) beryllium  d) potassium  e) cesium
Part II: Multiple Choice: (4 pts each). The answer you fill in on your bubble sheet is the one that will count. You should circle the answer on this sheet for your own reference.

14. As the reaction proceeds in a cylinder equipped with a moveable piston, 355 J of heat is released and the volume of the cylinder changes from 1.50 L to 20.50 L. The pressure in the cylinder is 1.00 atm at constant temperature of 398 K. Calculate the change in total energy ($\Delta E$) for the reaction in joules? [1 L· atm = 101.3 J]
   a) +1940 J   b) +1590 J   c) −374 J   d) −2280 J   e) −37886 J

15. What is the final temperature in degree Celsius when 60.0 mL of water at 80.0 °C is mixed with 40.0 mL of water at 20.0 °C. The specific heat of water is 4.184 J/g·°C. [density of water = 1.00 g/mL]
   a) 38.0 °C   b) 50.0 °C   c) 56.0 °C   d) 63.0 °C   e) 100.0 °C

16. Given the following data:
   \[2 \text{HCl}(g) \rightarrow \text{H}_2(g) + \text{Cl}_2(g) \quad \Delta H = +184.6 \text{kJ}\]
   \[2 \text{H}_2(g) + \frac{1}{2} \text{N}_2(g) + \frac{1}{2} \text{Cl}_2(g) \rightarrow \text{NH}_4\text{Cl}(s) \quad \Delta H = −314.4 \text{kJ}\]
   \[\text{N}_2(g) + 3 \text{H}_2(g) \rightarrow 2 \text{NH}_3(g) \quad \Delta H = −92.2 \text{kJ}\]
   Calculate the enthalpy change for the following reaction,
   \[\text{NH}_3(g) + \text{HCl}(g) \rightarrow \text{NH}_4\text{Cl}(s) \quad \Delta H = ? \text{kJ}\]
   a) −176 kJ   b) −222 kJ   c) −406.8 kJ   d) −591.2 kJ   e) +92.2 kJ

17. For the following reaction, \(2\text{NaCl}(s) + \text{F}_2 (g) \rightarrow 2\text{NaF} (s) + \text{Cl}_2(g) \quad \Delta H = −320 \text{kJ}\). How much energy would be released or absorbed when 3.0 mole of Cl₂ reacted with excess of NaF to give NaCl and F₂?
   a) + 960   b) +1000   c) +320   d) −320   e) −960

18. Calculate the energy of one mole of photon of red light with a frequency of \(4.00 \times 10^4 \text{s}^{-1}\)?
   [\(\text{NA} = 6.02 \times 10^{23}; \text{h} = 6.63 \times 10^{-34} \text{J.s; } \text{c} = 3.00 \times 10^8 \text{m/s}\)]
   a) \(1.66 \times 10^{-48} \text{J}\)   b) \(2.65 \times 10^{-19} \text{J}\)   c) \(6.63 \times 10^{-34} \text{J}\)   d) \(4.00 \times 10^{14} \text{J}\)   e) \(1.60 \times 10^{-5} \text{J}\)
Part-III: For full credit, show all your work legibly, include units, and report your answer to the correct number of significant figures. No work shown = 0 points.

19) (18 pts) 85.0 mL of 1.20 M nitric acid, HNO₃ at 23.1°C were allowed to react with 35.0 mL of 1.50 M potassium hydroxide, KOH at 23.1°C in a calorimeter with a small hole in the lid. The contents were stirred and the final temperature of the resultant solution was 24.3°C. Assume that the densities of all solutions are 1.00 g/ml and the specific heats of all solutions are 4.18 J/g°C.

a) (3 pts) Write a balanced chemical equation for this reaction. [Remember to show phases]

b) (2 pts) Clearly and specifically identify what is gaining heat and what is losing heat.

Gaining Heat: ___________________________ Losing Heat: ___________________________

c) (1 pt) Is the process exothermic or endothermic? (Circle one)

(i) exothermic  (ii) endothermic  (iii) neither endothermic nor exothermic

d) (6 pts) Calculate the heat, q_rxn, associated with this reaction, in units of kJ.

e) (2 pts) In the above reaction _____________________ is the limiting reagent. Justify your answer.

e) (4 pts) Calculate the enthalpy change for this reaction, ΔH_rxn, in units of kJ/mol of acid.
20) A) (4 pts) Calculate $\Delta H_{\text{rxn}}^\circ$ for the following reaction of propane ($C_3H_8$) with chlorine gas to produce carbon tetrachloride, $CCl_4$ and HCl gas,

$$C_3H_8(g) + 10Cl_2(g) \rightarrow 3CCl_4(l) + 8 HCl(g)$$

B) (5 pts) Calculate the amount of heat released (enthalpy change) when 5.00 g of propane reacted completely with excess of chlorine gas. [If you don’t have answer for part-a, use $\Delta H_{\text{rxn}}^\circ$ for the above reaction as $-955 \text{ kJ}$]

C) (5 pts) Calculate the amount (in mL) of carbon tetrachloride, $CCl_4$ produced if the reaction released only 346 kJ of heat energy. Density of $CCl_4 = 1.58 \text{ g/mL}$. [If you don’t have answer for part-a, use $\Delta H_{\text{rxn}}^\circ$ for the above reaction as $-955 \text{ kJ}$]
21. A) (2 pts) When we watch a fireworks display, the fireworks we see are a result of _______. (Choose one)

i) absorption of light when electrons change from a higher to lower energy level.

ii) emission of light when electrons change from a lower to higher energy level.

iii) emission of light when electrons change from a higher to lower energy level.

B) (5 pts) Calculate the energy (in kJ) of a photon during an electron transition from n=3 to n=2 energy level.

C) (1 pt) State whether energy is absorbed or emitted during this electronic transition?

Absorbed  Emitted

D) (4 pts) What will be the color of the light that one can observe during an electron transition from n = 3 to n = 2 energy level? Circle one. Explain. Support your answer with necessary calculation. Circling an answer with NO work will get NO credit!!

| The colors of the visible light spectrum |
|------------|-----------------|-----------------|
| color      | wavelength range | frequency range  |
| red        | ~ 700–635 nm     | ~ 430–480 THz   |
| orange     | ~ 635–590 nm     | ~ 480–510 THz   |
| yellow     | ~ 590–560 nm     | ~ 510–540 THz   |
| green      | ~ 560–490 nm     | ~ 540–610 THz   |
| blue       | ~ 490–450 nm     | ~ 610–670 THz   |
| violet     | ~ 450–400 nm     | ~ 670–750 THz   |

1 THz = $10^{12}$ Hz = $10^{12}$ s$^{-1}$
\[ q = m C_s \Delta T \quad q_{\text{solution}} + q_{\text{rxn}} = 0 \quad q_{\text{solution}} = -q_{\text{rxn}} \quad \Delta H_{\text{rxn}} = \frac{q}{\text{mol of limiting reactant}} \]

\[ q_v = -C_v \Delta T \quad \Delta E = q + w \quad w = -P\Delta V \]

\[ c = 3.00 \times 10^8 \text{ m/s} \quad c = \lambda \nu \quad E = h \nu \quad h = 6.63 \times 10^{-34} \text{ J} \cdot \text{s} \]

For hydrogen atoms: \[ E_n = -2.18 \times 10^{-18} \text{ J} \left( \frac{1}{n^2} \right) \]

\[ \Delta E = -2.18 \times 10^{-18} \text{ J} \left( \frac{1}{n_f^2} - \frac{1}{n_i^2} \right) \]

\[ \Delta x \Delta mv \geq \frac{h}{4\pi} \quad 1 \text{ nm} = 10^{-9} \text{ m} \]

\[ R_H = 1.096776 \times 10^7 \text{ m}^{-1} \quad \lambda = \frac{h}{mv} \]

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### Periodic Table of the Elements

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**Note:** This text represents a section from a book or document that includes equations, formulas, and a periodic table. The focus is on thermodynamics and quantum mechanics, with specific mentions of hydrogen atom energy levels and the relationship between wave numbers and angular momentum in quantum mechanics.