Please take a seat in Row_____  Seat_____

Please:

• **Keep this booklet closed until instructed to open it.**
• Turn off and remove from your person all electronic items including PDAs, cell phones, Iphones, Ipods, ear buds, pagers, computers, programmable calculators, and other similar devices. Place them in your purse or pack out of sight and hearing.
• Place all papers, periodic tables, books, coat, hat, pack, or purse at the front or back of the room, or on the floor.
• All you need are #2 pencils & a non-programmable calculator.
• After the exam begins, you may write in the exam booklet. Use the space to show work for your own records.

**Exam Directions**

☆ This is a closed book, 90-minute exam. That means use nothing but the materials supplied to answer the questions.
☆ There are a total of 11 pages in this exam, including the cover, back sheet, and scratch paper.
☆ The back sheet contains reference information including constants and periodic table.
☆ Write **YOUR NAME** on **THIS PAGE NOW**.
☆ Write **YOUR NAME**, the **LETTER of your exam**, and enter your **STUDENT NUMBER** on the **BUBBLE SHEET NOW**.
☆ Your exam grading may be **delayed** or even **prevented** if the above items are missing or incorrect.
Multiple Choice (4 pts each)
Identify the choice that best completes the statement or answers the question. CAREFULLY fill in the correct answer on the BUBBLE SHEET provided. Marks on this exam paper will NOT be graded, even if a mark here appears correct and the answer on the bubble sheet is incorrect.

1. Structural isomers are compounds that have
   a. the same molar masses, but different elemental composition.
   b. have identical structures, but contain different isotopes of the same elements.
   c. two or more resonance structures.
   d. the same elemental composition, but the atoms are linked in different ways.
   e. the same physical properties, but different chemical properties.

2. For which one of the following molecules do geometric (that is, cis/trans or E/Z) isomers exist?
   a. H₂C=CH₂
   b. BrHC=CHCl
   c. ClH₂C–CH₂Br
   d. H₃C–CH₂Cl
   e. H₂C=CCl₂

3. Which of the following molecules might be an alkyne?
   a. C₃H₆
   b. C₄H₁₀
   c. C₅H₁₀
   d. C₆H₁₀
   e. C₆H₁₂

4. What is the name of the following compound?
   \[
   \begin{align*}
   &\text{CH}_3 \\
   &\text{H}_3\text{C}–\text{CH} \\
   &\text{H}_2\text{C}–\text{CH} \\
   &\text{CH}_2–\text{CH}_3
   \end{align*}
   \]
   a. 1,1,3-trimethylpentane
   b. 2,4-dimethyloctane
   c. 3-methyl-4-propylbutane
   d. 3,5-dimethylhexane
   e. 2,4-dimethylhexane
5. How many isomers, both structural and geometric, exist for C₅H₁₀? Consider non-cyclic isomers only.
   a. 5
   b. 6
   c. 7
   d. 8
   e. 9

6. Which one of the following hydrocarbons is aromatic?
   a. 
   b. 
   c. 
   d. 
   e. 

7. Hydrogen bonding is present in all of the following molecular solids EXCEPT _____.
   a. H₂SO₄
   b. NH₃
   c. PH₃
   d. HF
   e. H₂O₂

8. As pure molecular solids, which of the following exhibits dipole-dipole intermolecular forces: HCl, Cl₂, SCl₂, and CCl₄?
   a. HCl only
   b. HCl and Cl₂
   c. HCl and SCl₂
   d. Cl₂ and CCl₄
   e. SCl₂ and CCl₄
9. What intermolecular force or bond is primarily responsible for the solubility of carbon dioxide (CO\textsubscript{2}) in water?
   a. dipole/dipole force
   b. hydrogen bonding
   c. dipole/induced dipole force
   d. hydrogen bonding-dipole force
   e. ion-induced dipole force

10. As pure molecular solids, which of the following exhibit only induced dipole/induced dipole forces: O\textsubscript{2}, CH\textsubscript{2}Cl\textsubscript{2}, and SO\textsubscript{2}?
   a. O\textsubscript{2} only
   b. CH\textsubscript{2}Cl\textsubscript{2} only
   c. SO\textsubscript{2} only
   d. O\textsubscript{2} and CH\textsubscript{2}Cl\textsubscript{2}
   e. O\textsubscript{2} and SO\textsubscript{2}

11. Arrange Cl\textsubscript{2}, ICl, and Br\textsubscript{2} in order from lowest to highest boiling point.
   a. Cl\textsubscript{2} < Br\textsubscript{2} < ICl
   b. Cl\textsubscript{2} < ICl < Br\textsubscript{2}
   c. ICl < Cl\textsubscript{2} < Br\textsubscript{2}
   d. Br\textsubscript{2} < Cl\textsubscript{2} < ICl
   e. Br\textsubscript{2} < ICl < Cl\textsubscript{2}

12. At its boiling point of –34.0 °C, 6.33 kJ of heat is required to vaporize 22.0 g of chlorine (Cl\textsubscript{2}). What is the molar enthalpy of vaporization of chlorine?
   a. 0.0893 kJ/mol
   b. 0.286 kJ/mol
   c. 1.96 kJ/mol
   d. 20.4 kJ/mol
   e. 139 kJ/mol

13. Which of the following phase transitions is/are exothermic?
   1. liquid water evaporating into the gas phase.
   2. the sublimation of solid carbon dioxide into the gas phase.
   3. gaseous butane condensing into a liquid at its boiling point of –0.5 °C.
   a. 1 only
   b. 2 only
   c. 3 only
   d. 1 and 2
   e. 1, 2, and 3
14. Which of the following are valid reasons why vegetable oil has a greater viscosity than diethyl ether, \( \text{CH}_3\text{OCH}_3 \)?
   1. Unlike diethyl ether, oil molecules are not held together by hydrogen bonds.
   2. Oil molecules have long chains that become entangled.
   3. Intermolecular forces are greater for the larger oil molecules.

   a. 1 only
   b. 2 only
   c. 3 only
   d. 1 and 3
   e. 2 and 3

15. Arrange the three common unit cells in order from least dense to most dense packing.

   a. face-centered cubic < body-centered cubic < primitive cubic
   b. primitive cubic < body-centered cubic < face-centered cubic
   c. primitive cubic < face-centered cubic < body-centered cubic
   d. body-centered cubic < primitive cubic < face-centered cubic
   e. body-centered cubic < face-centered cubic < primitive cubic

16. Tungsten crystallizes in a body-centered cubic unit cell. If the radius of a tungsten atom is 0.137 nm, what is the length of an edge of the unit cell?

   a. 0.119 nm
   b. 0.194 nm
   c. 0.274 nm
   d. 0.316 nm
   e. 0.548 nm

17. For a primitive cubic unit cell, what percentage of the space in the cell is occupied by the atoms at the corners of the cell?

   a. 47%
   b. 52%
   c. 68%
   d. 74%
   e. 87%
18. Which of the following compounds is expected to have the strongest ionic bonds?
   a. RbI
   b. RbF
   c. NaI
   d. CsBr
   e. LiF

19. The lattice energy of KF is $-821$ kJ/mol. This energy corresponds to which reaction below?
   a. $K(s) + \frac{1}{2} F_2(g) \rightarrow KF(s)$
   b. $K(g) + F(g) \rightarrow KF(s)$
   c. $K(g) + F(g) \rightarrow KF(s)$
   d. $K^+(g) + F^-(g) \rightarrow KF(s)$
   e. $K^+(aq) + F^-(aq) \rightarrow KF(s)$

20. Which statement concerning the phase diagram below is INCORRECT?

![Phase Diagram]

   a. Only the solid phase exists at point A.
   b. At point D, the triple point, all three phases (gas, liquid, and solid) are in equilibrium.
   c. Moving from point A to B results in a phase transition from solid to liquid.
   d. At point C, the solid and liquid phases are in equilibrium.
   e. Only the liquid phase exists at point B.

21. If 355 g of ethanol (C$_2$H$_5$OH) is added to 645 g of water, what is the molality of the ethanol?
   a. 0.550 $m$
   b. 7.71 $m$
   c. 11.9 $m$
   d. 21.7 $m$
   e. 55.0 $m$
22. Which of the following statements is/are CORRECT?
   1. Solubility is defined as the concentration of solute in equilibrium with undissolved solute in a saturated solution.
   2. If two liquids mix to an appreciable extent to form a solution, they are miscible.
   3. If two liquids mix completely in any proportion to form a solution, the resulting solution is supersaturated.
   a. 1 only
   b. 2 only
   c. 3 only
   d. 1 and 2
   e. 2 and 3

23. In which solvent should Na\(^+\) have the most negative enthalpy of solvation?
   a. CCl\(_4\)
   b. H\(_2\)O
   c. C\(_6\)H\(_6\)
   d. CS\(_2\)
   e. C\(_6\)H\(_{14}\)

24. Which action(s) will increase the equilibrium concentration of a non-reacting gas in water?
   1. decreasing the temperature of the water
   2. increasing the volume of water
   3. decreasing the pressure of the gas above the liquid
   a. 1 only
   b. 2 only
   c. 3 only
   d. 1 and 3
   e. 1, 2, and 3

25. Ideally, colligative properties depend only on the
   a. concentration of solute particles in a solution.
   b. molar masses of the solute particles in a solution.
   c. density of a solution.
   d. hydrated radii of the molecules or ions dissolved in a solution.
   e. partial pressure of the gases above the surface of a solution.

26. The vapor pressure of pure water at 55 °C is 118 mm Hg. What is the equilibrium vapor pressure of water above a mixture of 77.0 g ethanol (CH\(_3\)CH\(_2\)OH, molar mass = 46.07 g/mol) and 32.0 g water?
   a. 2.72 mm Hg
   b. 34.6 mm Hg
   c. 49.0 mm Hg
   d. 57.2 mm Hg
   e. 60.8 mm Hg
27. Which of the following aqueous solutions should have the lowest freezing point?
   a. pure H₂O
   b. 1 m MgBr₂
   c. 1 m RbI
   d. 1 m NH₃
   e. 1 m C₆H₁₂O₆
Part II.
For full credit, you must show all conversion factors and the final answer with complete units, use the correct number of significant figures, and round off correctly. WRITE CLEARLY: if the grader cannot read your writing, no credit will be assigned.

28. (9 pts) Draw formulas for FOUR alkene structural isomers having a molecular formula of C_7H_{14}. Provide correct systematic (I.U.P.A.C.) names for TWO.

29. (9 pts) Platinum (Pt) crystallizes in a face-centered cubic unit cell. In addition, platinum has an atomic radius of 139 pm. Calculate the density in g/cm^3 of platinum. (Please read the directions above and on p. 1.)
30. **(9 pts)** The boiling point of water is 100.000 °C at 1 atmosphere.

In a laboratory experiment, students synthesized a new compound and found that when 11.80 grams of the compound were dissolved in 270.0 grams of water, the solution began to boil at 100.124 °C. The compound was also found to be nonvolatile and a non-electrolyte.

Calculate the molecular weight of this compound.

(Please read the directions above and on p. 1.)
May be removed – but please do not rip out the staple.

| Avogadro’s number = 6.0221 x 10^{23} | Specific heat capacity of water = 4.184 J/(g·°C) |
| E_n = -Rhc/n^2 ;  R = 1.097 x 10^7 m^{-1}  | Speed of light (c) = 2.998 x 10^8 m s^{-1} |
| Circumference of circle = 2\pi r       | Gas constant (R) = 0.08206 L-atm/(K·mol) = 8.314 J/(mol·K) |
| Area of circle = \pi r^2                | Volume of sphere = \left(\frac{4}{3}\right)\pi r^3 |

Boiling Point Elevation/Freezing Point Depression

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Formula</th>
<th>K_b (°C/m)</th>
<th>K_f (°C/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>H_2O</td>
<td>0.512</td>
<td>-1.86</td>
</tr>
<tr>
<td>Ethanol</td>
<td>CH_3CH_2OH</td>
<td>1.22</td>
<td>-1.99</td>
</tr>
<tr>
<td>Chloroform</td>
<td>CHCl_3</td>
<td>3.67</td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>C_6H_6</td>
<td>2.53</td>
<td>-5.12</td>
</tr>
</tbody>
</table>