12. (10) A stream of each of the following liquids is discharged from a burette. In each case a positively charged rod is held near the stream.

\[ C_{10}H_{22} \quad C_{10}H_{19}OH \quad CCl_4 \]

a) Circle the formula for the liquid you think would be most deflected.
b) Would it be deflected toward or away from the rod?

c) Would this change if the rod were negatively charged?

13. (4) Distilled water containing bromthymol blue appears blue. When dry ice is dropped into this solution, bubbling occurs and the solution becomes yellow. Explain, including the chemical equation(s).

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CHEMISTRY 12H
Final Examination
December 9, 1996

NAME __________________________  __________________________
(first)  (last)

P.L.E.A.S.E., DO NOT USE INFORMATION STORED IN YOUR CALCULATOR MEMORY.
We trust you.

You have 110 minutes. Do all work on these pages. There is one blank page at the end if you need extra space. Please box your answers to numerical problems. Remember to include units and use the correct number of significant figures. You should answer the problems in whatever order you prefer. It is in your best interest to be as clear and complete as possible, but you should avoid spending too much time on one problem. There are 23 questions worth a total of 425 points.

\[ R = 8.3145 \text{ J K}^{-1} \text{ mol}^{-1} \quad h = 6.626 \times 10^{-34} \text{ J s} \]

PERIODIC TABLE OF THE ELEMENTS

(End of examination)
1. (45) Solid NH₄HS is introduced into an evacuated container at 24°C. The following reaction takes place:

\[ \text{NH}_4\text{HS}(s) \rightleftharpoons \text{NH}_3(g) + \text{H}_2\text{S}(g) \]

At equilibrium, some solid remains and the total pressure is 0.614 atm.

a) What is \( K_p \) at 24°C?

b) If \( \Delta H \) for this reaction is 80.0 kJ/mol, what would \( K_p \) be at 50°C?

e) At 24°C, what is the value of \( K_c \) for this reaction?

f) What is \( K_p \) for the reverse reaction at 24°C?

2. (40) Your text presents the following set of four reactions as the process wherein ozone is both formed and destroyed by sunlight (all substances are in the gaseous state):

\[ \text{O}_2 + \text{hv}_1 \rightarrow \text{O} + \text{O} \]
\[ \text{O} + \text{O}_2 + \text{M} \rightarrow \text{O}_3 + \text{M}_1^* \]
\[ \text{O}_3 + \text{hv}_2 \rightarrow \text{O}_2 + \text{O} \]
\[ \text{O} + \text{O} + \text{M}_2 \rightarrow \text{O}_2 + \text{M}_2^* \]

Given \( \Delta H^\circ \) in kJ/mol:
\[ \begin{array}{c|c}
\text{O} & 247.5 \\
\text{O}_3 & 142.3 \\
\end{array} \]

a) Write down the net result of these four steps.

c) If you compress the container to half its original volume, what total pressure would you observe after equilibrium is re-achieved at 24°C?

d) If 1 atm of argon were introduced into the container (original size) what would the final total pressure be at equilibrium (24°C)?

b) What is M? Why is it necessary?
c) What are the value and sign of the difference in energies of $M_1$ and $M_1^*$ in kJ/mol?

(15) Consider two samples of air at the same T and P. One sample is dry, the other is humid. Which is denser, the sample of dry air or the sample of humid air? Explain your reasoning.

d) What is the average O–O bond energy in O$_2$(g)?

e) What is the maximum wavelength of light that can accomplish the first reaction? What kind of light is this?

(10) If 78 seconds are needed for 1.000 L of N$_2$ to effuse through a porous barrier, how much time is needed for 1.000 L of UF$_6$ to effuse through the same barrier at the same temperature and pressure?
5. (20) Below are $\Delta H$ values for processes involving water (all in kJ/mol).

   a) 6.01  b) 40.67  c) 0.00  d) 50.95  e) -11.71  f) 44.94

The table lists $\Delta H$'s for 4 physical processes. Match each of these processes with the correct $\Delta H$ value by inserting the appropriate letter in the second column of the table.

<table>
<thead>
<tr>
<th>process</th>
<th>value letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta H_{\text{vap}}$ (100°C)</td>
<td></td>
</tr>
<tr>
<td>$\Delta H_{\text{vap}}$ (0.0°C)</td>
<td></td>
</tr>
<tr>
<td>$\Delta H_{\text{sub}}$ (0.0°C)</td>
<td></td>
</tr>
<tr>
<td>$\Delta H_{\text{lus}}$ (0.0°C)</td>
<td></td>
</tr>
</tbody>
</table>

5. (40) Consider the 4 samples described below:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>He(g) 25°C 1 atm</td>
<td>Xe(g) 25°C 1 atm</td>
<td>Xe(g) 400°C 1 atm</td>
<td>H$_2$O(l) 25°C 1 atm</td>
</tr>
</tbody>
</table>

Compare (larger, smaller, same)

Average kinetic energy of the molecules A vs. C. A is ________________

Average kinetic energy of the molecules A vs. D. A is ________________

Mean free path A vs. B. A is ________________

Number of molecules/L A vs. B. A is ________________

Number of molecules/L B vs. C. B is ________________

Average molecular speed A vs. B. A is ________________

Average molecular speed A vs. C. A is ________________

7. (10) Which of these liquids would you expect to have the higher surface tension? Explain your choice.

7. (10) Write the structure for the organic product of the reaction between one molecule of ethylamine and one molecule of propanoic acid.

9. (10) Name the product resulting from the reaction of bromine with 2-methyl-2-hexene.
10. (15) The boiling points for benzene, phenol, and toluene are listed below. Rationalize
the values as completely as you can.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>benzene</td>
<td>80</td>
</tr>
<tr>
<td>phenol</td>
<td>182</td>
</tr>
<tr>
<td>toluene</td>
<td>111</td>
</tr>
</tbody>
</table>

b) the shape (sketch, name)

c) the hybridization at P.

11. (10) Would you expect an aqueous solution of sodium acetate to be neutral, acidic, or
basic? Explain.

13. (15) In IR spectra of organic molecules you can see absorption peaks due to such things
as bond stretching (C=O, C≡C, C–C–C, C–H, C≡O) and bending (H–C–H, C–C–C, C–
C–O).

Which should have the higher frequency for each pair? (Circle).

a) C–C or C≡C stretch
b) C–C or C–H stretch
c) H–C–H bend or C–H stretch

14. (45) Complete the following reactions (no need to balance). If no reaction occurs, write
"no reaction." Show ionized products as separate aquated ions. Show physical
state (s, l, g, aq) of each product.

\[ \text{NaCl(aq)} + \text{H}_2\text{O(l)} \rightarrow \text{Ba(s)} + \text{H}_2\text{O(l)} \rightarrow \]
\[ \text{BaCl}_2(aq) + \text{Na}_2\text{SO}_4(aq) \rightarrow \]
\[ \text{Hg(NO}_3)_2(aq) + \text{Mg(s)} \rightarrow \]
\[ \text{Na}_2\text{O(s)} + \text{H}_2\text{O(l)} \rightarrow \]
\[ \text{SO}_2(g) + \text{CaO(s)} \rightarrow \]
15. (15) The phase diagram for pure CO₂ is shown below. Consider a sample of CO₂ under the conditions represented by point a.

a) What is the physical state of the sample?

b) What happens to this sample if it is compressed at constant temperature?

c) Pure CO₂ in a closed tube is observed at 25°C to have the appearance shown below:

- Upright
- Tipped

What is the pressure in the tube? (Mark the pressure on the pressure axis and make a rough estimate of its value. Indicate your reasoning.)

16. (20) The lattice energy of MgF₂ is 2910 kJ/mol. The ionic radius of Mg²⁺ is 0.65 Å and that for F⁻ is 1.33 Å. Calculate the percentage of the lattice energy that results from creation of a mole of individual MgF₂ components, before the components are brought together and arranged into a crystalline structure. The applicable constant is 1386 kJ Å²/mol au², where au refers to an atomic unit of charge.
17. (15) a) Two dyes have different colors in aqueous solution: one is blue, the other is red. Below are their visible spectra. Indicate on the figure which spectrum corresponds to which dye.

b) The absorbance of a colored 1.00 M aqueous solution at visible wavelength $\lambda_1$ is measured and found to be 0.217. A solution of the same solute of unknown concentration is found to have an absorbance of 0.139 at $\lambda_1$. What is the concentration of the unknown solution?

19. (10) Chlorine in the upper atmosphere catalyzes destruction of ozone. Emission of HCl from volcanoes dwarfs the amounts of chlorine-containing compounds injected into the atmosphere by human activities. Comment on the relevance of volcanic emission to the ozone hole. (Do studies indicate that volcanic emissions are an important factor?)

18. (10) Hexane extracts of spider webs (produced by soaking webs in hexane) failed to induce web reduction by male spiders when sprayed on inactive webs. On the other hand, extracts of webs by methanol were “active” in inducing web reduction. The pheromone was ultimately identified to be 3-hydroxybutyric acid (and related dimer, trimer, etc.).
   a) Draw the molecular structure of the pheromone.

20. (10) Methyl bromide, produced in biomass fires, has a much shorter lifetime in the atmosphere than chlorofluorocarbons (ca 20-60 yrs for chlorofluorocarbons compared to 2 years for methyl bromide). As a result, inorganic Br amounts are less than 1% of inorganic chlorine concentrations in the stratosphere. However, Br may be very significant in deterioration of the ozone layer. Why?
21. (10) What homonuclear diatomic neutral molecule is paramagnetic and singly bonded? (containing an element having atomic number ≤ 10). Show your logic, using clear labels.

23. (20) Consider the reaction \( \text{Cl}_2(g) \rightleftharpoons 2 \text{Cl}(g) \)

   a) Indicate whether \( K_p \) should be very large, very small or around 1 at room temperature. Briefly explain your reasoning.

   b) What effect would you expect an increase in \( T \) to have on \( K_p \) for this reaction? Explain.

cc. (10) Aluminum has these successive ionization energies in kJ/mol: 577, 1816, 2744, 11600. Estimate \( I_3 \). Indicate your reasoning.