CHEMISTRY 104 – Summer 2025
Hour Exam 2 Answers

Multiple Choice (3 points each)

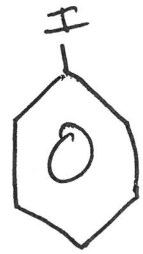
1.	E	14.	C
2.	A	15.	B
3.	E	16.	D
4.	B	17.	D
5.	B	18.	E
6.	C	19.	C
7.	D	20.	A
8.	A	21.	B
9.	D	22.	E
10.	B	23.	A
11.	A	24.	A
12.	E	25.	D
13.	C		

Written out problems – Show all work for partial credit.

26. **Write the structural formula** for the **major** organic product in each of the following chemical reactions. For the organic product, **name** the compound.

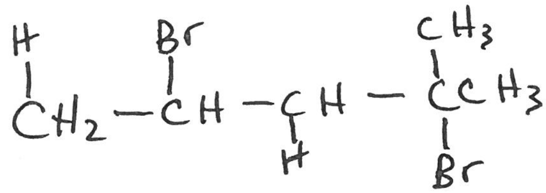
(9)

a) $C_6H_6 \xrightarrow[FeI_3]{I_2}$



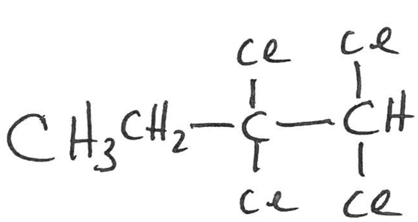
iodobenze

b) $CH_2{=}CH{-}CH{=}C(CH_3)CH_3 \xrightarrow{\text{HBr (excess)}}$



2,4-dibromo-2-methylpentane

c) $CH_3CH_2{-}C{\equiv}CH \xrightarrow{Cl_2\text{ (excess)}}$

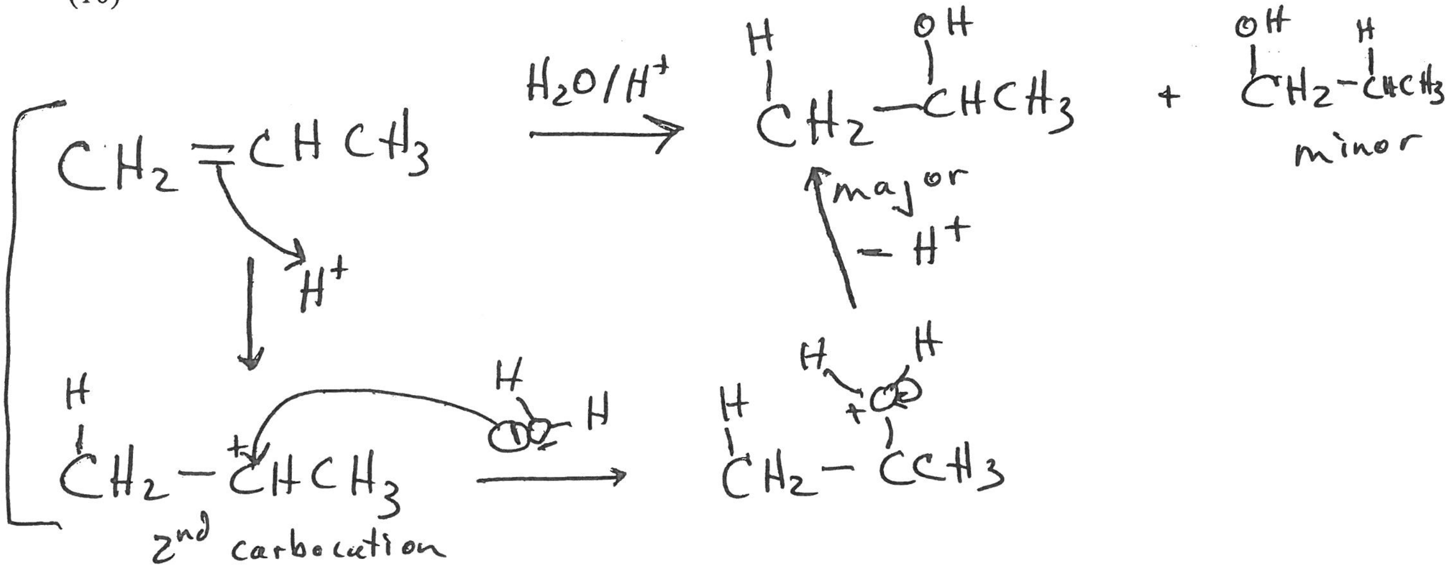


1,1,2,2-tetrachlorobutane

27. When H_2O is reacted with 1-propene in the presence of H^+, two products are obtained. Propose a detailed mechanism for the major product formed from this reaction. Explain why the major product is preferred over the minor product.

(10)

8pts

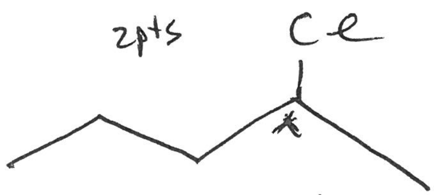


2pts A secondary carbocation is produced for the major product and a primary carbocation is produced for the minor product. Since a secondary carbocation is more stable than a primary carbocation, the major product is prefered.

28. a) Two of the structural isomers of $C_5H_{11}Cl$ have a chiral carbon, i.e, is optically active. Name the structural isomers that are optically active.

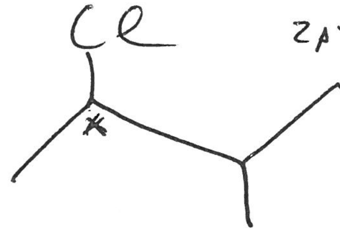
(11)

2pts



2-Chloropentane

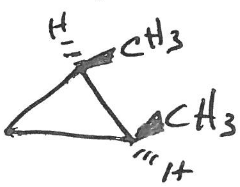
2pts



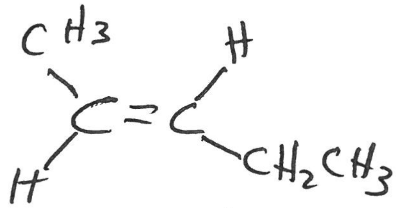
2-chloro-3-methylbutane

b) Two of the structural isomers with the formula C_5H_{10} exhibit geometric (cis/trans) isomerism. Name the two structural isomers.

2-pentene (2pts) and 1,2-dimethylcyclopropane (2pts) exhibit cis/trans isomerism.



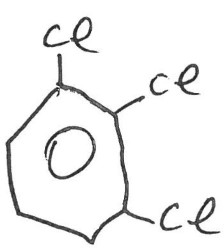
This is cis form of 1,2-dimethylcyclopropane.



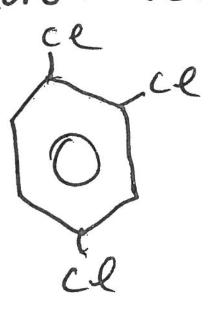
This is the trans form of 2-pentene.

c) Name the structural isomers of trichlorobenzene.

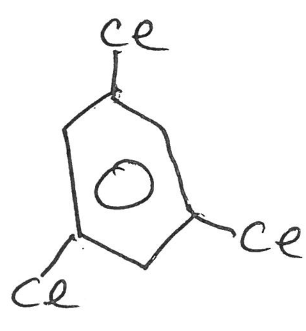
1,2,3-trichlorobenzene (1pt), 1,2,4-trichlorobenzene (1pt), and 1,3,5 trichloro benzene (1pt) are the 3 ~~isomers~~ structural isomers of trichlorobenzene.



1,2,3-



1,2,4-



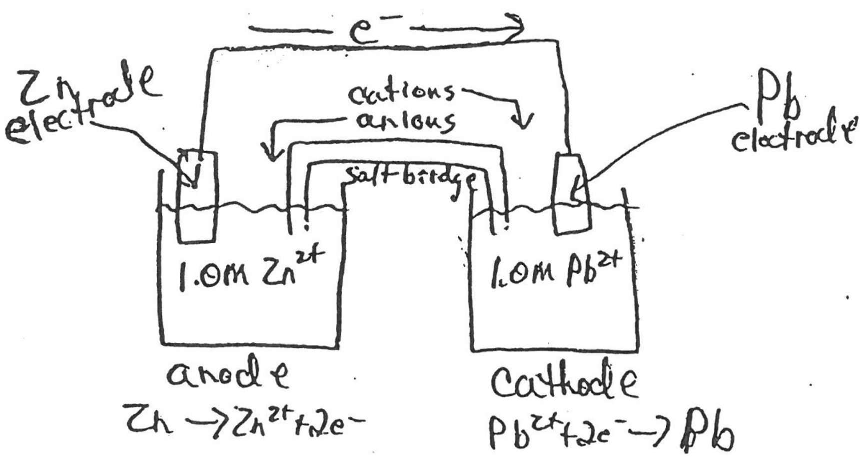
1,3,5-

29. (12) Consider a galvanic cell at 25°C based on the following half-reactions:

$$Pb^{2+} + 2e^- \rightarrow Pb \qquad E° = -0.13\ V$$
$$Zn^{2+} + 2e^- \rightarrow Zn \qquad E° = -0.76\ V$$

8 pts

a) Draw the cell under **standard** conditions labeling the anode, the cathode, the direction of electron flow, the concentration of ions, the electrodes, and the direction of flow of cations and anions through the salt bridge.



$$Pb^{2+} + 2e \rightarrow Pb(s) \quad E°_{red} = -0.13V$$
$$Zn(s) \rightarrow Zn^{2+} + 2e^- \quad E°_{ox} = +0.76V$$
$$\underbrace{Pb^{2+} + Zn \rightarrow Pb + Zn^{2+} \quad E°_{cell} = 0.63V}_{\text{For part b.}}$$

4 pts

b) To the standard cell above, OH^- is added to the zinc compartment causing $Zn(OH)_2$ to precipitate. After equilibrium is reached, the measured cell potential is 1.05 V. Given the following K_{sp} value for $Zn(OH)_2$:

n = 2 electrons transfered

$$Zn(OH)_2(s) \longrightarrow Zn^{2+}(aq) + 2\ OH^-(aq) \qquad K_{sp} = 6.5 \times 10^{-17} = [Zn^{2+}][OH^-]^2$$

calculate the equilibrium $[OH^-]$ in the zinc compartment.

$$E = E° - \frac{0.0591}{n} \log Q = 0.63\ V - \frac{0.0591}{2} \log \frac{[Zn^{2+}]}{[Pb^{2+}]}$$

$$1.05V = 0.63V - \frac{0.0591}{2} \log \frac{[Zn^{2+}]}{1.0M}; \quad \log[Zn^{2+}] = \frac{-0.42(2)}{0.0591}$$

$$\log[Zn^{2+}] = -14.21, \quad [Zn^{2+}] = 10^{-14.21} = 6.2 \times 10^{-15}\ M$$

$$K_{sp} = [Zn^{2+}][OH^-]^2, \quad 6.5 \times 10^{-17} = (6.2 \times 10^{-15})[OH^-]^2$$

$$[OH^-]^2 = \frac{6.5 \times 10^{-17}}{6.2 \times 10^{-15}} = 0.0105, \quad [OH^-] = \sqrt{0.0105} \boxed{= 0.10M = [OH^-]}$$

30. Hydrogen-oxygen fuel cells are utilized in some cities to produce electricity. The fuel cell reaction and equilibrium constant at 25°C are:

(9)

$$\overset{0}{2\,H_2(g)} + O_2(g) \rightarrow \overset{+1}{2\,H_2O(l)} \qquad K = 1.28 \times 10^{83}$$

The oxidation state of each H atom increases from 0 to +1, with 4 mol of H in balanced rxn, $n = 4(1) = 4$ electrons transfered.

a) Fuel cells produce power by producing a voltage. Calculate E°, the standard cell potential, for this fuel cell reaction at 25°C.

$$E^\circ = \frac{0.0591}{n}\log K = \frac{0.0591}{4}\log(1.28\times10^{83}) = 1.23\,V$$

b) This fuel cell utilizes the following half-reactions:

	E°
$4\,H_2O(l) + 4e^- \rightarrow 2\,H_2(g) + 4\,OH^-(aq)$	–0.83 V
$O_2(g) + 2\,H_2O(l) + 4e^- \rightarrow 4\,OH^-(aq)$	?

Using your result from part a, and given the information above, calculate the standard reduction potential for:

$O_2(g) + 2\,H_2O(l) + 4e^- \rightarrow 4\,OH^-(aq)$ E° = 1.23 V (from part a)

$2H_2 + 4OH^- \rightarrow H_2O + 4e^-$ $\quad \mathcal{E}^\circ_{ox} = 0.83\,V$

$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$ $\quad \mathcal{E}^\circ_{red} = ?$

$2H_2 + O_2 \rightarrow 2H_2O$ $\quad \mathcal{E}^\circ_{cell} = 0.83 + \mathcal{E}^\circ_{red} = 1.23\,V$

$\mathcal{E}^\circ_{red} = 1.23 - 0.83 = 0.40\,V$

c) The reverse reaction of this fuel cell:

$2\,H_2O(l) \rightarrow 2\,H_2(g) + O_2(g)$ 4 electrons transfered

can be used to produce hydrogen and oxygen gases in an electrolytic cell. How many moles of $O_2(g)$ can be produced if water is electrolyzed by a current of 10.0 amps for 220 minutes?

$$220\,\text{min}\left(\frac{60\,s}{1\,\text{min}}\right)\left(\frac{10.0\,C}{s}\right)\left(\frac{1\,\text{mol}\,e^-}{96{,}485\,C}\right)\left(\frac{1\,\text{mol}\,O_2}{4\,\text{mol}\,e^-}\right) = 0.34\,\text{mol}\,O_2$$

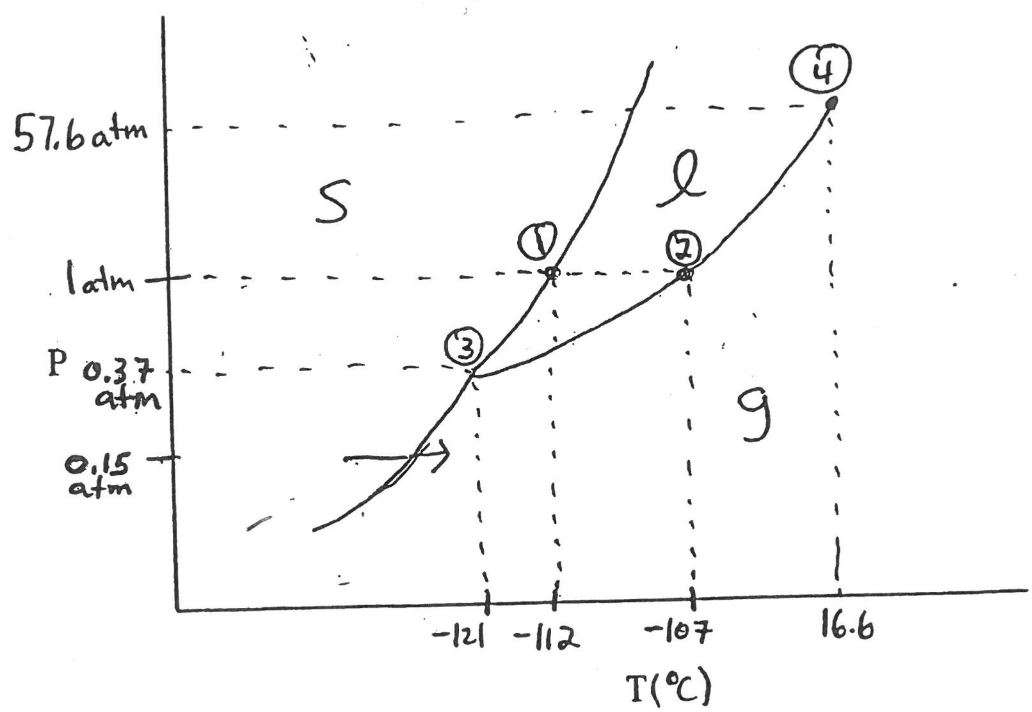
31. Like most substances, xenon exists in one of three typical phases: solid, liquid and gas. Some important data points in the phase diagram for xenon are:

(12)

1. normal melting point = –112°C
2. normal boiling point = –107°C
3. triple point = –121°C and 0.37 atm
4. critical point = 17 °C and 58 atm

a) Sketch the phase diagram (P vs. T) for Xe, showing the four data points given above (label them 1-4) as well as indicating the area in which each phase is stable (label the various areas solid, liquid or gas). Your phase diagram does **not** have to be to scale. However, on your axes indicate the pressures and temperatures for the four data points given above.

8 pts



b) For the following four questions, circle the correct response.

1 pt i) Which is the denser phase, Xe(s) or Xe(l)?
From positive slope of solid–liquid equilibrium line

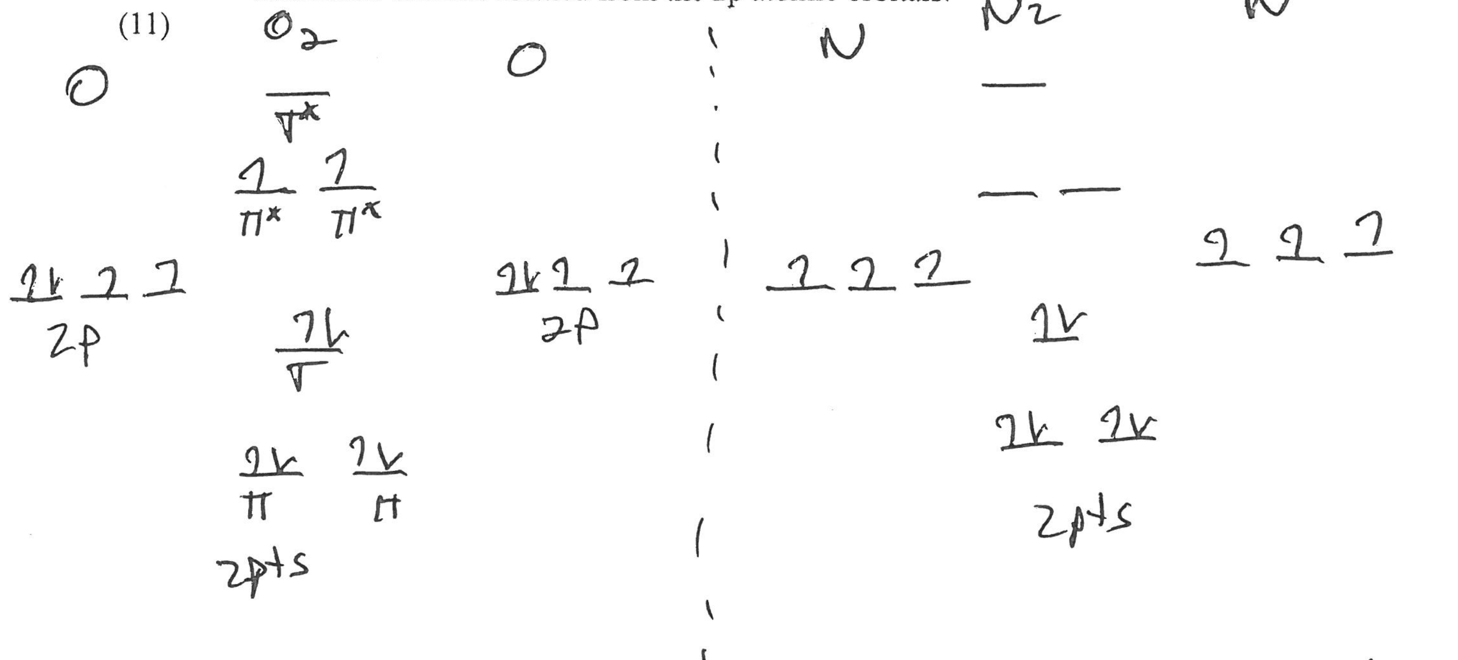
1 pt ii) As pressure increases, does the melting point of xenon increase or decrease?
From positive slope of Solid–liquid equilibrium line

1 pt iii) As pressure increases, does the boiling point of xenon increase or decrease?
From positive slope of liquid–gas line.

1 pt iv) If solid xenon is heated at a constant pressure of 0.15 atm, will Xe(s) sublime or melt? See arrow at 0.15 atm. Xe(s) will sublime to form Xe(g).

32. 4pts a) Draw the molecular orbital diagrams for O_2 and N_2. Only draw the diagrams for the molecular orbitals formed from the 2p atomic orbitals.

(11)



2pts b) Is O_2 **paramagnetic** or **diamagnetic**? Circle your answer. Has unpaired electrons.

Is N_2 **paramagnetic** or **diamagnetic**? Circle your answer. All electrons are paired.

3 pts c) Explain why the removal of one electron from O_2 strengthens the bond, while the removal of one electron from N_2 weakens the bond.

The bond order of O_2 is $(6-2)/2 = 2$. When O_2 loses an electron to form O_2^+, an antibonding electron is lost. The bond order for O_2^+ is $(6-1)/2 = 2.5$. When O_2 loses an electron, the bond order increases, so the bond strengthens.

The bond order for N_2 is $(6-0)/2 = 3$. When N_2 loses an electron to form N_2^+, a bonding electron is lost. The bond order for N_2^+ is $(5-0)/2 = 2.5$. When N_2 loses an electron, the bond order decreases, so the bond weakens

2pts d) Does the O_2 molecule have a **larger** or **smaller** ionization energy than O atoms? Circle your answer. O_2 loses an electron from π^*, which is higher in energy than the 2p electron which is lost for O atoms. So easier to remove e^- from O_2.

Does the N_2 molecule have a **larger** or **smaller** ionization energy than N atoms? Circle your answer.

N_2 loses an electron from σ orbital, which is lower in energy than the 2p electron which is lost for N atoms. It is harder (takes more energy) to remove an electron ~~from~~ from N_2 as compared to N atoms.