

Chemistry 158 Summer 2007 Midterm Examination

100 points; each question carries equal credit.

Your name in block capitals and CIN:

Instructor's Key

I understand that this exam is designed to measure my understanding and that cheating on it will result in a zero grade for this exam as well as review by the appropriate academic authorities.

(your signature)

You are allowed one 3x5" card with equations and data (both sides acceptable) BUT no copies of homework solutions; a calculator; writing instruments.

The last page is a periodic table.

Grading of questions with essay answers (1, 2, 1, 6, 9, 10) reflects my judgment of both content & style: A, 100%; B, 80%; C, 60%.

Hg

1. What was revolutionary about the discoveries of Roentgen, Becquerel, and the Curies? Describe two twentieth century discoveries that developed from the work of these pioneers.

Notes for answer: Roentgen - X-rays - structures of materials incl. DNA

Becquerel + Curies - radioactivity - isotopes - tracers - atomic bomb - nuclear power

10

- 2.1 Hypothesis: Microwave ovens heat all foods to the same temperature in the same amount of time. Formulate a set of experiments to test this hypothesis and describe possible outcomes of your experiments.

Take 3 very different foods: e.g. soup; oatmeal; pizza
Heat each from same starting temp. for same time (3 min?),
in same microwave oven.
Check temp of each at end.

5

Outcomes: all at same T so hypothesis confirmed
OR: all at different T " " rejected

- 2.2 The metric prefix giga- (G) represents one billion, 10^9 times the associated base unit. The distance from earth to sun is 150 Gm, and the velocity of light is 3×10^8 m/s. How many minutes does it take for light from the sun to reach the earth? (60s/min).

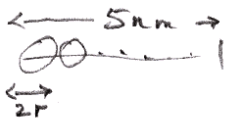
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$$\text{velocity} = \frac{\text{dist.}}{\text{time}} \quad \text{so } t = d/v = \frac{150 \text{ Gm} \times 10^9 \text{ m/Gm} \cdot \frac{1 \text{ min}}{60 \text{ s}}}{3 \times 10^8 \frac{\text{m}}{\text{s}}}$$

$$= 8.3 \text{ min} \quad \left(\begin{array}{l} \text{2 digits only} \\ \underline{150 \text{ Gm}} \end{array} \right) \quad \begin{array}{l} \text{Show work} \\ \text{or credit} \end{array} \downarrow$$

Show work throughout or
credit ↓

3.1 The radius of a tellurium atom is 143 pm. How many touching tellurium atoms will fit on to a line that is 5 nm long? (nm = 10^{-9} m; pm = 10^{-12} m.)



$$\# \text{ atoms of Te} = \frac{5 \text{ nm} \times 10^{-9} \text{ m/nm}}{2 \times 143 \text{ pm} \times 10^{-12} \text{ m/pm}}$$

4

$$= 17$$

(34 radii gets 3/4)

3.2 The molecular formula for benzoic acid, a food preservative, is $\text{C}_7\text{H}_6\text{O}_2$; a) what is the molar mass of benzoic acid in g/mol? B) A 25 mg sample of benzoic acid is added to a can of peaches. How many molecules of benzoic acid is this? (Avogadro's number = 6.02×10^{23} .)

$$\text{a) Molar mass} = (7(12.011) + 6(1.008) + 2(15.999)) \text{ g/mol}$$

3

$$= 122.12 \text{ g/mol}$$

B) # molecules in 25 mg

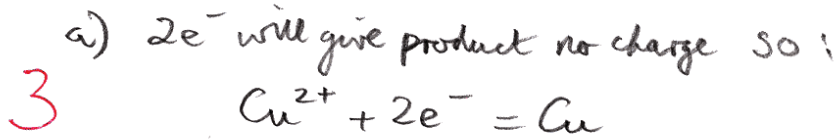
$$= \frac{25 \text{ mg} \times 10^{-3} \text{ g/mg}}{122.12 \text{ g/mol}} \times 6.02 \times 10^{23} \text{ molecules/mol}$$

3

$$= 1.2 \times 10^{20} \text{ molecules} \quad (2 \text{ sig. figs only} - \underline{25} \text{ mg})$$

4.1 The equation $\text{Cu}^{2+} + 2 \text{ electrons} = \text{Cu}^+$ doesn't make sense as written.

a) How can you correct it? b) Is your corrected equation an oxidation or a reduction?



b) e^- are being added so: reduction

3

4.2 You are a scientist who has created in a nuclear reactor 300 atoms of the element with $Z = 116$. You have determined that there are 3 isotopes of masses respectively of 232 amu, 234 amu, and 235 amu. How many neutrons are present in the nuclei of each of these 3 isotopes, AND how many electrons are present in the neutral atoms of each isotope?

Let's call the element X , $Z = 116$

$\begin{smallmatrix} 232 \\ 116 \end{smallmatrix} X$ must have $232 - 116 = 116$ neutrons

$\begin{smallmatrix} 234 \\ 116 \end{smallmatrix} X$ " " $234 - 116 = 118$ " — | ea

$\begin{smallmatrix} 235 \\ 116 \end{smallmatrix} X$ " " $235 - 116 = 119$ " — |

4 and each neutral atom must have
116 electrons to balance the
nuclear charge (Z) of +116 |

5. a) Explain why the usual anions of sulfur, chlorine and tellurium are S^{2-} ; Cl^- ; and Te^{2-} respectively.

The "rule" of 8 (octet rule) means ions will have # valence $e^- = \#$ in next noble gas

So: S & Te in group 6A with 6 v.e.

add $2e^- \rightarrow 8$ v.e. + S^{2-} , Te^{2-}

Cl in group 7A with 7 v.e.

adds $1e^- \rightarrow 8$ v.e. + Cl^-

6

b) What is unlikely about the formation of the anions Ne^- and Xe^{2-} ?

They would have 9 & 10 v.e., respectively
— more than the magic # of 8.

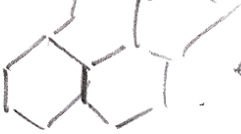
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BONUS: Why is it hard to add electrons to noble gas atoms?

Because they would exceed the 8 v.e.
— in more detail because the next available energy level is well above the filled ($8e^-$) energy level

+2

6. Describe two allotropes of carbon including structures and properties. How do the properties of the allotropes you describe depend on the allotrope's structure?

Diamond: 3d network of 6
 membered rings

 etc. Hard, transparent,
 good heat conductor
 — from rigid framework.

Graphite

 sheets of
 hexagons
 weakly
 bonded.

Opaque, slippery — lubricant
 "lead" pencils.

or you could pick C₆₀ or nanotubes.

Graded as an essay.

7. Phosphorus is an essential element in living beings.

a) Use your knowledge of electron pair structures to predict which ONE of the following molecules is most likely to exist:

PO_4 PBr_7 PCl_3 PS_2

P is in group 5A & has 5 v.e. = so needs
3 more to share - & so PCl_3 is best bet;
 not PO_4 (4 or 8 v.e. extra); PBr_7 (7 v.e. extra);
 PS_2 (2 or 4 " ").

5

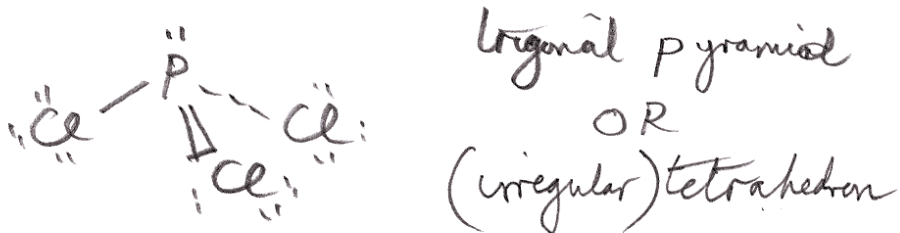
No reasons: 3/5

b) Use VSEPR to describe the molecular geometry of your answer to part a).



5

4 sets around P (3 bonding, 1 lone-pair)
 based on tetrahedron & so



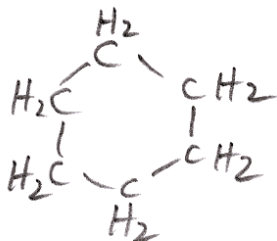
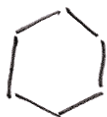
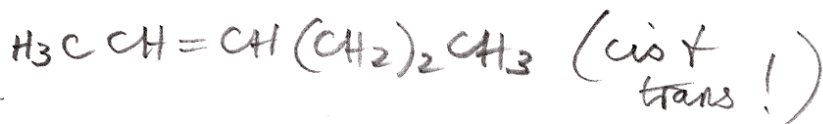
No reasons 3/5

1 for each correct \rightarrow 12, ⁸ possible points total!

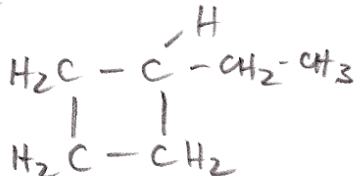
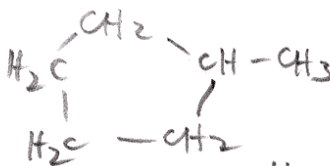
8. Draw SIX different isomers in both condensed and line notations for molecules of formula C_6H_{12} .

Two H short of C_nH_{2n+2} (C_6H_{14})

so one double bond or one ring.



etc etc!



9. Write at least 45 accurate words about helium.

Essays ↗
↓

10. Write at least 45 accurate words about John Dalton.