Midterm 2 Worksheet

The problems in this review are designed to help prepare you for your upcoming exam. Questions pertain to material covered in the course and are intended to reflect the topics likely to appear in the exam. Keep in mind that this worksheet was created by CARE tutors, and while it is thorough, it is not comprehensive. In addition to exam review sessions, CARE also hosts regularly scheduled tutoring hours.

Tutors are available to answer questions, review problems, and help you feel prepared for your exam during these times:

Session 1: 23 October, 4-6 pm Greg, Jonathan, and Sera

Session 2: 25 October, 7-9 pm Jesse and Sera

Can’t make it to a session? Here’s our schedule by course:

https://care.grainger.illinois.edu/tutoring/schedule-by-subject

Solutions will be available on our website after the last review session that we host.

Step-by-step login for exam review session:

1. Log into Queue @ Illinois: https://queue.illinois.edu/q/queue/902
2. Click “New Question”
3. Add your NetID and Name
4. Press “Add to Queue”

Please be sure to follow the above steps to add yourself to the Queue.

Good luck with your exam!
1. A molecule has molar mass 180.18 g/mole and is 40.00% C, 6.73% H, and 53.28% O. What is its molecular formula?

40 g C / 12 g/mol = 3.33 mol C
6.73 g H / 1.008 g/mol = 6.67 mol H
53.28 g O / 16 g/mol = 3.33 mol O

Divide by 3.33 → CH2O empirical; mass = 30 g → 180/30 = 6
Molecular formula = 6*empirical

\[
C_6H_{12}O_6
\]

2. What is the definition of an electrolyte? Give some examples of strong, weak and non-electrolytes

Substance that conducts electric current as a result of a dissociation into positively and negatively charged ions, which migrate toward and ordinarily are discharged at the negative and positive terminals (cathode and anode) of an electric circuit, respectively

Strong Electrolytes → Compounds that completely dissociate: Salts, strong acids or bases (NaCl, KBr, NaOH, HI, etc)
Weak Electrolytes → Compounds that weakly dissociate (Acetic Acid, Carbonic Acid, Ammonia, etc)
Non-Electrolytes → Compounds that don’t really dissociate (Glucose)

3. Which of the following will conduct electricity best?

a) Ethanol C2H6O
c) Urea CO(NH2)2
b) Water H2O
d) Nitric Acid NH43

The strongest acid conducts electricity the best. Nitric Acid is the strongest acid out of the options. Therefore, the answer is (d).

4. What are the ionic and net ionic equations for the following reactions?

(I) CaCl2 (aq) + FeSO4 (aq) → CaSO4 (s) + FeCl2 (aq)

(II) SrCl2 (aq) + NiSO4 (aq) → SrO4 (aq) + NiCl2 (aq)

(I) Ionic equation: Ca^{2+}(aq) + 2Cl^-(aq) + Fe^{2+}(aq) + SO^{2-}_4(aq) → CaSO4(s) + Fe^{2+}(aq) + 2Cl^-(aq)
Net ionic equation: Ca^{2+}(aq) + SO^{2-}_4(aq) → CaSO4(s)

(II) Ionic equation: Sr^{2+}(aq) + 2Cl^-(aq) + Ni^{2+}(aq) + SO^{2-}_4(aq) → Sr^{2+}(aq) + SO^{2-}_4(aq) + Ni^{2+}(aq) + 2Cl^-(aq)
Net ionic equation: No net ionic equation because all the substances are in the aqueous state.
Only elements producing a precipitate (solid state) are left in the net equation.
5. Given a stock solution: 4L of 6M HCl.

(a) Determine the volume of the stock solution needed to make 10 liters of a 2M solution.

(b) What volume of 0.1M solution could you make with the remaining stock?

(a) Desired outcome \((M_2V_2) \rightarrow (10L)(2M)\)

\[ M_1V_1 \text{ (stock)} = M_2V_2 \]

\[ 6V_1 = (10L)(2M) = 20 \rightarrow V_1 = \boxed{3.33L} \]

(b) Starting with 4L, you now have 4 - 3.33 = 0.67L leftover

\[(0.67L)(6M) = V_{\text{resultant}}(0.1M) \rightarrow V_{\text{resultant}} = \boxed{40.2L} \]

6. Calculate the mass percent composition of the following compound

\(C_3H_4O_2\)

\[ \text{C: } \left( \frac{12.01 \times 3}{72.062} \times 100 \% \right) = 50\% \]

\[ \text{H: } \left( \frac{1.008 \times 4}{72.062} \times 100 \% \right) = 5.6\% \]

\[ \text{O: } \left( \frac{16 \times 2}{72.062} \times 100 \% \right) = 44.4\% \]

7. Molecule: BrF₅

Find the geometry, shape, bond angles and polarity:

Geometry: Octahedral, Shape: Square Pyramidal, Bond Angles: 90, Polarity: Polar

8. Determine the molecular geometry of the following compounds.

A) KrF₂

B) PCl₅

C) XeF₄
D) TeF₄  
E) ICl₃

Draw the Lewis structure of each compound to determine their geometry. KrF₂ is linear; PCl₅ is trigonal bipyramidal; XeF₄ is square planar; TeF₄ is seesaw; and ICl₃ is T-shape.

9. Which of the following compounds will be least soluble in water? Hint: Water is a polar solvent and “like dissolves like”

A) KrF₂  
B) PF₃  
C) IF₅  
D) COS  
E) SO₂

The answer is (A) KrF₂. It has a linear shape so the electrons are evenly distributed across the molecule, which makes it a nonpolar compound. Since water is a polar solvent, it will be the least soluble in water. (PF₃ is trigonal pyramidal; IF₅ is square pyramidal; and SO₂ is bent. All these geometries result in asymmetrical distribution of electrons and make them polar. COS is a linear molecule, but O is more electronegative than S, which also makes it a polar compound.)

10. Circle the following compounds that are polar.

a) CF₄  
b) SF₄  
c) KrCl₂  
d) PCl₅  
e) SeF₂

The molecular geometry can help determine whether a compound is polar or nonpolar. CF₄ is tetrahedral; SF₄ is seesaw; KrCl₂ is linear; PCl₅ is trigonal bipyramidal; and SeF₂ is bent. Seesaw and bent shaped molecules have asymmetrical distribution of electrons, which make them polar molecules. The answer is (B) and (E).

11. Which has a higher boiling point?

a) Ethanol (vapor pressure 10 mm Hg)  
b) Water (vapor pressure 8 mm Hg)  
c) Diethyl ether (vapor pressure 12 mm Hg)  
d) Acetone (vapor pressure 13 mm Hg)

The answer is (b) Water. Water has the lowest vapor pressure and therefore has the strongest intermolecular forces, thus it has the highest boiling point.

12. Answer the following questions regarding water and acetone (CH₃COCH₃).

(a) Draw the Lewis structure for each.
(b) Name the inter-molecular forces present in each
(c) Rank the boiling point and vapor pressure.

(a) The left molecule is acetone, and the right one is water.

(b) Acetone has London dispersion and dipole-dipole forces. Water has London dispersion, dipole-dipole, and hydrogen bonds.
(c) Water has a higher BP and lower VP due to higher inter-molecular forces.

13. 75 mL of 0.2M Al(NO\(_3\))\(_3\) with 100 mL of 0.2 M K\(_2\)CO\(_3\) react to form a precipitate. How many moles of the precipitate form?

0.075L*0.2M = 0.015 moles Al(NO\(_3\))\(_3\)

0.1L*0.2M = 0.02 moles K\(_2\)CO\(_3\)

2:1 ratio between Al(NO\(_3\))\(_3\) and Al\(_2\)(CO\(_3\))\(_3\)
3:1 ratio between K\(_2\)CO\(_3\) and Al\(_2\)(CO\(_3\))\(_3\)

0.015 moles Al(NO\(_3\))\(_3\) * 1/2 - 0.0075 moles Al\(_2\)(CO\(_3\))\(_3\)

0.02 moles K\(_2\)CO\(_3\) * 1/3 - 0.00667 moles Al\(_2\)(CO\(_3\))\(_3\)

K\(_2\)CO\(_3\) is limiting - 0.00667 moles formed

14. Consider the products for the following four aqueous reactions.

(I) K\(_2\)S (aq) + NaCl (aq) →

(II) AgNO\(_3\) (aq) + MgCl\(_2\) (aq) →

(III) CuCl\(_2\) (aq) + Na\(_2\)SO\(_4\) (aq) →

(IV) Li\(_2\)CO\(_3\) (aq) + Ni(NO\(_3\))\(_2\) (aq) →

Which reaction result in the formation of a precipitate?

a) (II), (III), and (IV)  
c) (I), (II) and (III)  
e) (II) and (III)

b) (I) and (III)  
d) (II) and (IV)
(I) The products are KCl (aq) + Na₂S (aq). Based on solubility rules, compounds of K⁺ or Na⁺ are always soluble.

(II) The products are AgCl (s) + Mg(NO₃)₂ (aq). Based on solubility rules, Ag⁺ is an exception for Cl⁻ and forms a precipitate. All compounds of NO₃⁻ are soluble.

(III) The products are CuSO₄ (aq) + 2NaCl (aq). Compounds of SO₄²⁻ are soluble with some exceptions, but Cu²⁺ is not one of them. The same logic applies to Cl⁻ compounds.

(IV) The products are LiNO₃ (aq) + NiCO₃ (s). All compounds of NO₃⁻ are soluble. However, most CO₃²⁻ compounds are insoluble and form precipitate.

The answer is therefore (d).