ENVIRONMENTAL CHEMISTRY INVITATIONAL EXAM

PATRICK O'NEILL, DEC 2009

peoneill@indiana.edu

SCHOOL NAME: ANSWER KEY

TEAM NO.: X

STUDENT NAMES:

Patrick O'Neill

Atomic #	Symbol	Element	Atomic Mass
1	H	Hydrogen	1.0
6	C	Carbon	12.0
7	N	Nitrogen	14.0
8	O	Oxygen	16.0
11	Na	Sodium	23.0
12	Mg	Magnesium	24.3
16	S	Sulfur	32.1
17	Cl	Chlorine	35.5
20	Ca	Calcium	40.1
29	Cu	Copper	63.5

Relative Isotope Abundance of Common Elements:

Element	Isotope	Relative Abundance	Isotope	Relative Abundance	Isotope	Relative Abundance
Carbon	^{12}C	100	^{13}C	1.11		
Hydrogen	^{1}H	100	^{2}H	.016		
Nitrogen	^{14}N	100	^{15}N	.38		
Oxygen	^{16}O	100	^{17}O	.04	^{18}O	.20
Sulfur	^{32}S	100	^{33}S	.78	^{34}S	4.40
Chlorine	^{35}Cl	100			^{37}Cl	32.5
Bromine	^{79}Br	100			^{81}Br	98.0

I. GENERAL CHEMISTRY

1. C_2H_2 is the molecular formula for ethylyne (A.K.A. acetylene).
(a) How many atoms are in one molecule?
(b) Which atoms make up acetylene?
(c) How many atoms are in one mole of acetylene?
(d) How many molecules are in 5.3 moles of acetylene?

(A) 4 +1

(B) Carbon and hydrogen +2

(C) $6.022 \times 10^{23} \times 4 = 2.41 \times 10^{24}$ atoms +2

(D) $6.022 \times 10^{23} \times 5.3 = 3.2 \times 10^{24}$ molecules +2

2. $Mg(OH)_2 + (NH_4)_2SO_4 \rightarrow MgSO_4 + H_2O + NH_3$
a) Balance the above reaction with coefficients.
b) How many grams of $Mg(OH)_2$ do you need to use in the above reaction to produce 500g $MgSO_4$?

(A) $Mg(OH)_2 + (NH_4)_2SO_4 \longrightarrow MgSO_4 + 2H_2O + 2NH_3$ +3

(B) $Mg(OH)_2$: $24.3 + 16\times2 + 2\times1 = 58.3$ g/mol

$MgSO_4$: $24.3 + 32.1 + 4\times16 = 120.4$ g/mol

+5

$$500.\text{ g } MgSO_4 \times \frac{\text{mol } MgSO_4}{120.4\text{ g } MgSO_4} \times \frac{1\text{ mol } Mg(OH)_2}{1\text{ mol } Mg(SO_4)} \times \frac{58.3\text{ g } Mg(OH_2)}{1\text{ mol } Mg(OH)_2} = 242\text{ g } Mg(OH)_2$$

pg subtotal 15

II. DILUTION AND SERIAL DILUTIONS

4 total

1. How would you make 25 mL of 20.% ethanol from a 95% ethanol stock?

$$C_1V_1 = C_2V_2$$

$$(95\%)(V_1) = (20\%)(25\,mL)$$

$$V_1 = 5.26\,mL \quad +3$$

add 5.26 mL 95% ethanol to 19.74 mL H_2O +1

7 total

2. A waste container containing 6.00kg of an organic pollutant leaks into a lake that has a surface area of 2km^2 and an average depth of 3m. Assuming the pollutant has diffused throughout the lake, is it more appropriate to us percentage, parts per thousand, parts per million, or parts per billion to discuss the concentration of this pollutant. ANSWER MUST BE JUSTIFIED BY CALCULATION/ESTIMATES.

Lake volume $\approx 2km^2 \times 3m$ (3m $\downarrow$ .003km) $= .006km^3$ (+1) $\times \left(\frac{1{,}000m}{km}\right)^3 = 6\times10^6 m^3 \times \left(\frac{100cm}{m}\right)^3 = 6\times10^{12} cm^3 = 6\times10^{12} mL$ +2

Mass of organic pollutant $\approx 6.00kg = 6{,}000g$

$\rightarrow$ about $\frac{6\times10^3 \text{ pollutant}}{6\times10^{12} \text{ water}} = \frac{1\times10^9 \text{ dilution}}{}$ (+2) = about 1 ppb

use +2 parts per billion!

4 total

3. If you were to dilute fish liver oil to 1.0×10^{-5}, and then found that the concentration of a pollutant was 2.5 pg / L in that dilution, what was the concentration of that pollutant in undiluted fish liver oil?

pg = picogram = $g \times 10^{-12}$ +1

$$\frac{2.5g \times 10^{-12}}{L} \times \frac{1}{10^{-5}} = \frac{2.5\times10^{-7} g}{L} \quad (+2) \qquad \left(= \frac{250ng}{L}\right)$$

(inverse of +1 dilution factor)

5 total

4. If you have a stock solution of 3.0 M potassium chloride (KCl, a powder), how would you make up 200. ml of a 5.0 µM (micromolar) solution of KCl?

$$\text{dilution factor} = \frac{\text{initial concentration}}{\text{final concentration}} = \frac{3M}{5\times10^{-6}M} = 6\times10^5 \quad +2$$

(★) +2 Break dilution into actionable steps: $\frac{1}{6\times10^5} = \frac{1}{6} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10}$

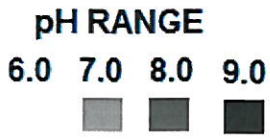
(★) +1 Actions: 1mL 3M KCl → 5mL H_2O → KCl Soln A; 1mL → 9mL H_2O → KCl Soln B; 1mL → 9mL H_2O → KCl Soln C; 1mL → 9mL H_2O → KCl Soln D; 1mL → 9mL H_2O → KCl Soln E; 1mL → 9mL H_2O → 10mL 5µM KCl

pg subtotal /20

III. SOIL TESTING

5 total

1.  Give the value of the pH for a soil sample with this result. Is it acidic, basic, or neutral? Is this a probable cause for concern?



pH = 6.5 - 7.5 +3 (1pt for pH = 7.0; 2pts for pH ≈ 7.0)

This pH is neutral. +1

This is not probable cause for concern. +1

5 total

2. Give the value of the pH for a soil sample with this result. Is it acidic, basic, or neutral? Is this a probable cause for concern?

pH ≤ 6.0 +3 (NO CREDIT for pH=6.0... you need to recognize the limitations and bounds of your tool!)

This pH is acidic. +1

This is not probable cause for concern as soil pH as low as 5.3 is considered normal. +1

IV. PLANT NUTRIENTS

CIRLCE THE CORRECT ANSWER ALL 20 multiple choice Qs are 2pts each... = 40pts total

1. Which of the following is a macronutrient?

A) Potassium B) Oxygen C) Silt D) Cheeseburgers

2. Which of the following is a micronutrient?

A) Nitrogen B) Clay C) Iron D) Cesium

3. Phosphorus is absorbed into plants in what form?

A) PH_3 B) P_4O_6 or P_4O_{10} C) PCl_3 or PBr_3 D) $H_2PO_4^-$ or HPO_4^{2-}

4. Which macronutrient causes high pH when in excess, which then precipitates many micronutrients so that they become unavailable to plants?

A) Nitrogen B) Sulfur C) Calcium D) Phosphorus

5. A deficiency of which macronutrient causes reduced growth, shortened inter-nodes, marginal burn or scorch (brown leaf edges), necrotic (dead) spots in leaves, a reduction of lateral bud breaks, and a tendency to wilt readily?

A) Potassium B) Nitrogen C) Oxygen D) Phosphorous

6.) If deficient, toxic levels of urea accumulate, leading to the formation of necrotic lesions.

A) Iron B) Nickel C) Molybdenum D) Cesium

pg subtotal

/22

V. REMEDIATION TECHNIQUES

Use the following answer choices for this section:

A) In Situ Oxidation B) Stabilization C) Solidification

D) Pump and Treat E) SEAR

E 1) Risky if the geology of the area is too porous as it can wash contaminants into other areas or deeper parts of the soil.

C 2) Falling out of favorability due to the CO_2 emissions from the large amount of concrete it requires.

A 3) Can damage the soil by killing off the natural bacteria.

A 4) The injection of chemicals as hydrogen peroxide, ozone gas, potassium permanganate or persulfates is used.

D 5) Although both cost-effective and able to quickly address severe soil pollution problems, this form of remediation is not very effective when contaminant levels are low (but still unacceptably high).

VI. SOIL COMPOSITION

Use the following answer choices for this section:

A) Sand B) Silt C) Clay D) Loam

D 1) A combination of the other three main soil types.

D 2) The best for horticulture.

A 3) The most coarse soil type.

C 4) The most resistant to temperature changes (has the highest specific heat).

A 5) Drains the most readily after a heavy rain.

C 6) Heaving may occur as a result of freezing and thawing, pushing plants out of the soil.

B 7) Individual particles can only be seen with a light microscope.

C 8) Individual particles can only be seen with an electron microscope

B 9) Composed primarily of quartz and feldspar

pg subtotal /28

VIII. MASS SPECTROSCOPY

2 total

1.) What is the molecular weight of CH_4?

$C = 12 \quad 4H = 4 \times 1 = 4 \quad = 16.0\ u$ (+1 +1)

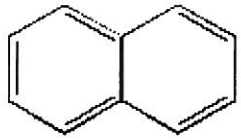
+2

2.) The molecular weight of a substance is an odd number. Which compound below could it be (circle)?

A) C_2H_6 B) CO_2 C) $C_6H_{12}O_6$ **D) $C_3H_7O_3N$** E) C_6H_6 F) H_2O

5 total

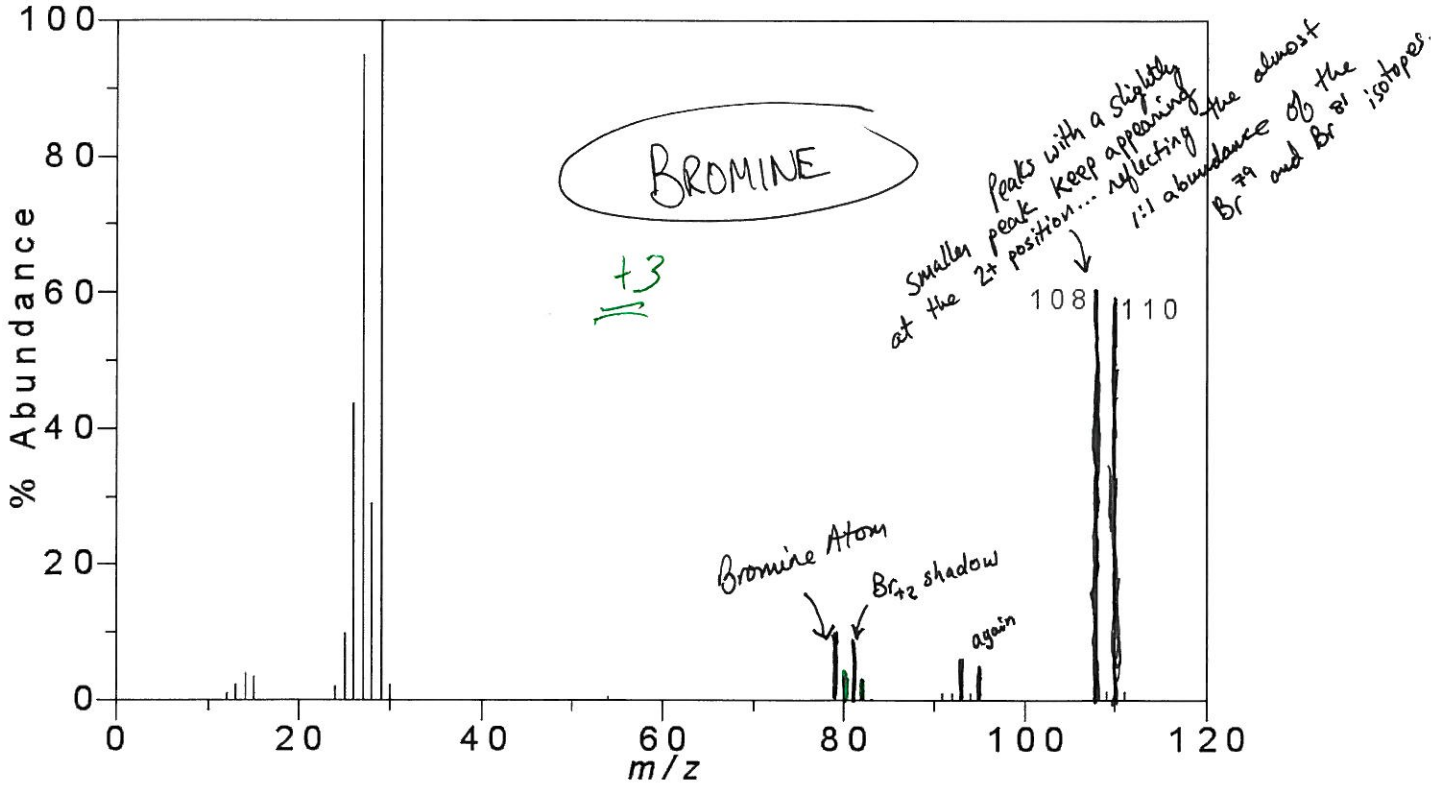
3.) Why would this molecule be easy to identify using mass spec?



This molecule is incredibly stable (+1) due to its aromatic rings (+1) and will not break apart easily (+1), meaning it will have a strong signal at its actual molecular mass (+2) with minimal other signals.

+3

4.) What element is conspicuously present in the mass spectrogram below?



3 total

5. What are the three primary components of a mass spectrometer?

+1 1. ION SOURCE (ionizer)

+1 2. MASS ANALYZER (also acceptable: orbitrap, ion trap, time-of-flight analyzer)

+1 3. DETECTOR

Pg subtotal /15