Welcome to Environmental Chemistry - C at Camas Invitational.

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1. (1.00 pts)   Which of the following gas is most soluble in water?
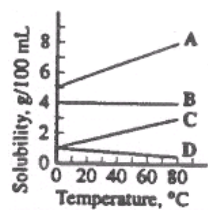
- ● A) Ammonia
- ○ B) Hydrogen
- ○ C) Methane
- ○ D) Nitrogen

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2. (1.00 pts)   Which of the following species dissociates most completely in water?

- ○ A) NH_4^+
- ○ B) H_2CO_3
- ● C) HNO_3
- ○ D) HSO_4^-

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3. (1.00 pts)

The aqueous solubility chart below compares several compounds within 80 ^oC range. Which can be recovered with the highest percentage yield by dissolving a sample in water at 8 ^oC and cooled to 0 ^oC?

- ○ A) A
- ○ B) B
- ● C) C
- ○ D) D

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4. (1.00 pts)   Which compound below is most soluble in water?

- ● A) Ethylamine
- ○ B) Chlorobenzene
- ○ C) Methyl acetate
- ○ D) Pentate

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5. (1.00 pts)   In deep brine wells concentration of bromine can be as high as 5000 parts per million by mass. What is the concentration when expressed as a mass percentage?

○ A) 0.005%

○ B) 0.05%

◉ C) 0.5%

○ D) 5%

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6. (1.00 pts)   Which of the following gas is least soluble in water?

◉ A) H_2
○ B) CO_2
○ C) NH_3
○ D) SO_4

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7. (4.00 pts)
Describe in a few words the statistical effect of outliers shown below for A and B (where the dashed line is fitted with the outlier present, and the solid line is fitted with the outlier removed). [2 pts]
Describe in one to two sentences the implication of r correlation in the plot C. [2 pts]
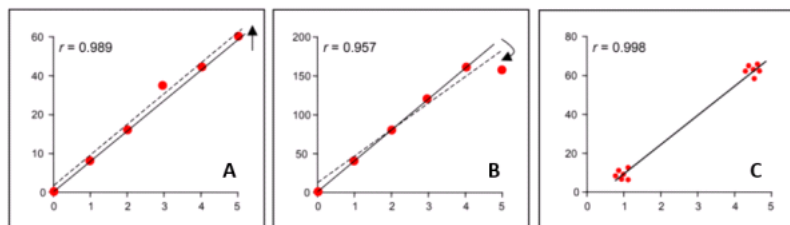
Expected Answer: (A) Outlier causes bias (B) Outlier cause shift in leverage (incorrect gradient and intercept); (C) This is poor experimental design, not strong correlation because of groups of points are distinct.

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8. (3.00 pts)   The correlation coefficient, R^2, can be interpreted in the following way:

(Mark **ALL** correct answers)
☑ A) The closer it is to 1, the stronger the correlation.

☐ B) The coefficient is also a measure of linearity;

☑ C) For predictions made from the calibration curve to have small uncertainties, R^2 needs to be very close to 1

☑ D) A low R^2 value does not necessarily mean that there is no correlation.

☐ E) None of the above is correct

The table below shows a set of data collected on the absorbance of a solution versus concentration. - Use this for the next two questions

Concentration /mg L^{-1}	Absorbance		
2.56	0.320		
5.12	0.591		
8.192	0.920	0.918	0.920
10.24	1.135		
12.80	1.396		

9. (9.00 pts)   If you were to draw a linear fit $y = mx + n$ where y is absorbance, x is the concentration in the unit given, what are the value of m and n?
What is the R^2 value (four significant figure)?

| 0.1054 | 0.0533 | 0.9999 |

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10. (4.00 pts)
What is the name of the law that describes the relationship between concentration and absorbance as shown in the previous question? (box 1)
If for a particular solution, we observed absorbance of 0.871, what is the predicted mg L^{-1} of the sample? (box 2)
And if we find the prediction interval (range of standard deviation) is 0.0414 mg L^{-1} at absorbance of 0.871, what is the 95% confidence interval for your prediction in mg L^{-1} unit?
(Input just the numeric value in box 3)

| Lambert-Beer law, or Beer l | 7.76 | 0.106 2pts (1pt for 0.081) |

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11. (6.00 pts)
Ideally, a calibration curve of absorbance versus the concentration of analyte in a series of standard solutions should be a straight line as in above questions. However, some cases the curve is nonlinear and can have both negative and positive deviations as shown below:
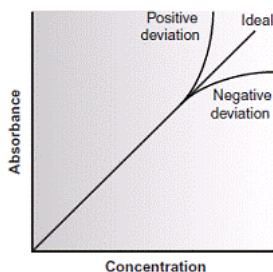
(a) Describe briefly (1 sentence) the fundamental limit to the law that governs the standard curve, which may explain above deviations. [2 pts]
(b) List two sources on instrument limitations or scenarios that may cause above deviation [2 pts]
(c) For weak acid type of standard solutions, it may show positive and negative deviations. Explain briefly the cause and remedy [2 pts]

Expected Answer: (a) Beer's law is only valid at low concentrations. (b) (1pt) Wavelength selector may leak other wavelength in (stray radiation) (1pt) Linearity is valid at one wavelength, close to broad peak region (vs. sloped part of spectrum)> (c) In weak acid, ion concentration is sensitive to pH, absorbance may depend on concentration in different wa for [HA] and [A-]. Solution is to add buffer.

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12. (2.00 pts)   What is the final concentration in µg/mL after following steps?

1. Pipette 6.0 mL of 5.0 µg/mL methylene blue working solution into a 15 mL conical tube.
2. Pipette 4.0 mL DI H2O into the tube to make 10.0 mL of total solution.
3. Seal the tube and invert repeatedly to mix.

| 3.0 |

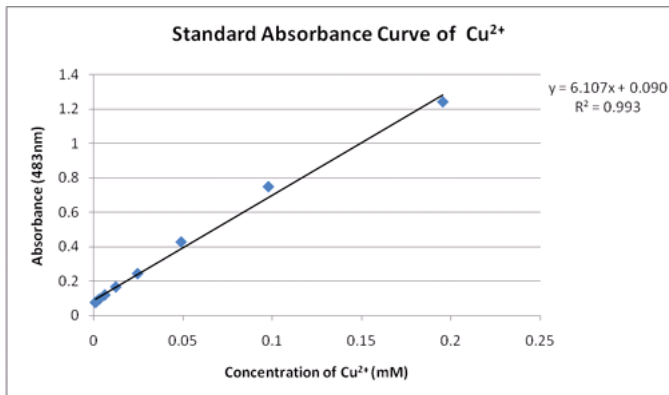**13. (2.00 pts)**   Identify the common dye with absorbance versus wavelength in data below.

λ (nm)	A		λ (nm)	A
400	0.429		570	0.974
425	0.208		575	0.966
450	0.196		580	0.936
475	0.271		585	0.878
500	0.406		600	0.599
525	0.650		625	0.208
550	0.871		650	0.056
555	0.900		675	0.013
560	0.928		700	0.003
565	0.954			

- ○ A) Erythrosine (Cherry red)
- ○ B) Allura Red AC
- ● C) Bromphenol blue
- ○ D) Tartrazine (Lemon yellow)
- ○ E) Aniline purple

14. (6.00 pts)
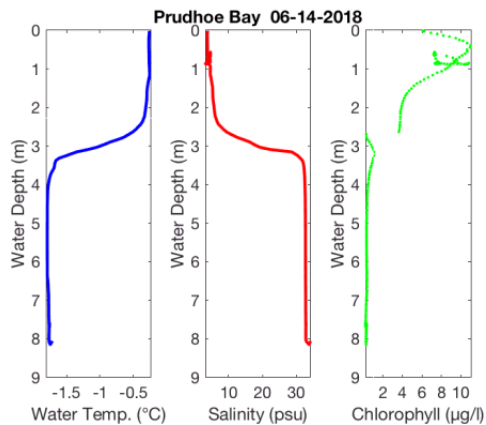
The following standard curve is obtained with serial dilution.

(a) If we started with 0.2 mM of Cu^{2+}, and follow the same dilution factor each step, how many steps of dilution are needed to get the a concentration of 0.003125 mM? (box 1)

(b) What is the predicted ppm concentration based on an absorbance of 1.00? (box 2)

(c) Cu^{2+} is toxic at high concentrations, generally the limit is 1.30 mg/L for extended exposure in drinking water. What is the minimum absorbance for samples exceeding such limit? (box 3)

Standard Absorbance Curve of Cu^{2+}

$y = 6.107x + 0.090$
$R^2 = 0.993$

Absorbance (483nm) vs Concentration of Cu^{2+} (mM)

6	9.47	0.215

Prudhoe Bay 06-14-2018

Water Depth (m) vs Water Temp. (°C) / Salinity (psu) / Chlorophyll (µg/l)

Use the CTD plot to answer the following three questions.

15. (2.00 pts)

Average ocean salt water salinity ranges between 32-36psu. What can you conclude from the profile of salinity and temperature (think about the rate that these factors change)?

Expected Answer: There is a surface layer of fresh, warm water till a depth of 3m.

16. (1.00 pts)   What does the Chlorophyll profile indicate of activities at the surface?

Expected Answer: There is active Primary Biological Production, indicates amount of phytoplankton and such present.

17. (1.00 pts)   The profile is collected with an instrument shown in picture below. What is the name for this instrument/technique?

Expected Answer: CTD

18. (3.00 pts)

Two sewage outfalls, Richmond and Hopewell, are located on an estuary some 40 km apart. Their associated pollution profile, expressed in mg/l BOD, is shown in the first figure. The second figure shows the resulting DO deficit for each outfall and for the sum of both. The observed oxygen levels (in unit of mg/L) are shown as points in the last figure, together with the dissolved oxygen distribution derived from the DO deficit curve.
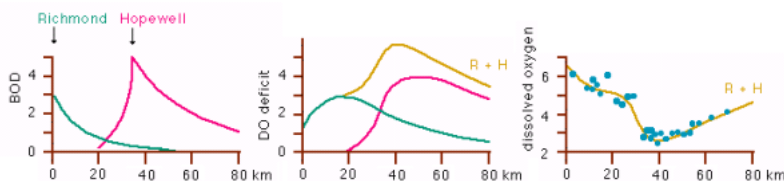
(a) Based on the BOD profile, is the pollutant conservative or non-conservative?
(b) What do conservative and non-conservative in this case mean?
(c) If the minimum required oxygen level is 3 mg/L, is there a location in the estuary where the it is unsafe for marine life?

Expected Answer: (a) Non-conservative ■ (b) Conservative pollutants are not normally physically/chemically/biologically transformed to non-toxic substances in the receiving water (and vice versa). ■ (c) Yes, near 40 km location

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19. (2.00 pts)   If 10 mL of 2.5 M $SrCl_2$ is diluted to 500. mL, what is the final concentration of Cl^- ions?

0.1 M

Use thermodynamic data listed below for the following two questions.

Species	ΔG_f^o (kJ/mol)	ion size (Å)
Pb^{2+}	-23.891	4.5
Cl^-	-131.290	3.0
$PbCl_2$(cotunnite)	-314.100	
$PbCl^+$	-163.385	4.0

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20. (5.00 pts)   Calculate equilibrium constants for the dissolution of cotunnite ($PbCl_2$). Constant R=8.314472 J/mol·K
Describe the steps to get full points.

Expected Answer: ΔG = -23.89 + 2*-131.379 – (-314.100) = 27.629 kJ/mol ■ Ksp = exp(-ΔG/RT) = exp[(-27.629 kJ/mol * 1000 J/KJ)/(8.314472 J/mol·K * 298.15 K)] ■ Ksp = 1.4441E-5 ■

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21. (10.00 pts)   Calculate the equilibrium concentrations of Pb^{2+} and Cl^- in terms of molalities. Assume that no complexation occurs and ideal-solution behavior.
Describe the solution steps to get full points.

Expected Answer: Ksp = [Pb2+][Cl-]]**2 = [Pb2+](2[Pb2+])**2 = 4[Pb2+]**3 ■ [Pb2+] = (Ksp/4)**(⅓) = 1.534 x 10**(-2) m ■

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22. (2.00 pts)   Discuss what are water quality standards vs. water quality criteria.

Expected Answer: WQS - Overall standards to determine water quality of a body of water. Includes designated uses, water quality criteria, and antidegradation policies. WQC - Included under WQS. General narrative statements and numerical chemical/biological/physical/radioactive concentrations or amounts required.

(Questions 23-26) One summer's day, you are strolling along a very large lake. Nature envelops you, from the trees and flowers, to the cute macroinvertebrates in the water. Howeve as you continue on your walk, you notice that there is an odd looking pipe discharging into the lake. You think to yourself, how might this water pollution affect the lake environment?

Thus, you decide to visit 6 of these drainage outfalls (supposedly from wastewater treatment facilities) and collect samples of water. You first determine the concentration of bacteria in the water (in CFU/mL) and find the COD (in mg/L) for each of the samples. The data you obtained is shown below.

Disclaimer: This scenario is mostly likely not possible in real life, neither is the data.

Conc. of Bacteria (CFU/mL)	COD (mg/L)
38.71	375
7.75	260
52	500
12.82	305
24.46	335
76.77	588

23. (1.00 pts) How is COD usually measured?

Expected Answer: Usually through oxidation (e.g. with potassium dichromate) of the wastewater in acidic conditions, and determining the oxidant left over with titration (colorimetric) Also w/ colorimeter/spectrophotometer.

24. (2.00 pts) Calculate the R^2 value for this data set (to 4 significant figures).

97.02%

25. (2.00 pts) What does this range of COD values show about the quality of the wastewater being discharged?

Expected Answer: Some of these sewage outfalls (e.g. the one with 260 mg/L COD) likely have undergone comparatively acceptable treatment, while others are insufficient or may have been part of CSOs, overflow/bypass situations.

26. (1.00 pts) Why might COD measurements be used as an alternative to BOD?

Expected Answer: COD takes less time to test for (BOD is 5 days, COD takes a couple).

27. (1.00 pts)   Which of these bodies of water/wetlands would not be considered a water of the United States?

○ A) A river that originates in the United States but also has smaller tributaries in Canada.

○ B) A wetland that is only saturated with water during parts of the year.

◉ C) Areas of groundwater recharge that arise from surface water infiltration.

○ D) A perennial stream contributing surface water flow to other navigable waters.

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28. (2.00 pts)   Which of the following requires a NPDES permit to discharge pollutants?

(Mark **ALL** correct answers)

☐ A) Industrial facility discharging pollutants into a municipal sanitary sewer system

☐ B) Agricultural return flows from irrigating fields

☑ C) Paper mill discharging wastewater into a nearby river

☑ D) Concentrated animal feeding operations

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29. (2.00 pts)

Types of residual chlorine left for disinfection after chlorine demand has been met include free chlorine and combined chlorine. Discuss these two terms as they apply to chlorine added to water for disinfection (in potable water treatment)

Expected Answer: Free chlorine - concentration of chlorine available for disinfection, composed of dissolved hypochlorite ions, hypochlorous acid and chlorine gas Combined chlorine - concentration of chlorine combined with organic/inorganic nitrogen compounds in the water (not as effective for disinfection), composed of chloramines

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30. (3.00 pts)   Residual chlorine may be measured through colorimetric methods. How might this be accomplished?

Expected Answer: Using a colorimeter, reagents (substances) added cause the water to change color and the meter reads the intensity of the color change by emitting a wavelength of light. OR not digitally, using reagents (such as OTO solution, DPD tablets/powders) and comparing the color in the water to a certain scale.

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31. (2.00 pts)   a) What is a sanitary sewer (what types of wastewater does it receive)?

b) What is the other kind of sewer that is used to address nonpoint source pollution due to wet-weather conditions?

Expected Answer: a) Sewer that conveys liquid and water-carried wastes from residences, commercial buildings, institutions NOT storm/surface/ground waters or industrial plants/factories b) Storm sewers

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32. (3.00 pts)

Three of the most common sources of impairment of bodies of water are nutrients, pathogens, and sediments. For each of these contaminants, identify an analyte mentioned in the rules that it is likely to be correlated with and explain why, also discuss what negative impact these contaminants may have on the environment.

Expected Answer: nutrients - phosphorus (increase nutrient load) - excess nitrogen/phosphorus cause cause algal blooms, leading to hypoxia and eutrophication pathogens - residual/low-level chlorine (less means more possibility of pathogens) - can have either acute/chronic affect on organisms, such as disease, death, etc. sediments - total dissolved solids + salinity (increases this) - clog fish gills, reduce light penetration (so less photosynthesis), fill up lake/stream/river bottoms

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33. (2.00 pts)
According to Section 404 of the Clean Water Act, dredge/fill material from which of the following are allowed to be disposed into navigable waters (if they meet effluent limits)?

(Mark **ALL** correct answers)

- ☑ A) Agriculture or silvicultural activities
- ☐ B) Nonindustrial construction sites
- ☑ C) Maintenance of structures like dikes, dams, levees, etc.
- ☑ D) Construction of farm/forest roads

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34. (1.00 pts) What is the difference between bypass and overflow when it comes to wastewater in publicly owned treatment works?

- ○ A) Overflow refers to diversion of wastewater flow during any point, bypass refers to diversion as treated wastewater exits the POTW.
- ○ B) Bypass refers to diversion of wastewater flow during any point, overflow refers to diversion as treated wastewater exits the POTW.
- ○ C) Overflow refers to diversion of wastewater flow during any point, bypass refers to diversion before the wastewater enters the POTW.
- ● D) Bypass refers to diversion of wastewater flow during any point, overflow refers to diversion before the wastewater enters the POTW.

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35. (2.00 pts) a) What does GC-MS analysis stand for?

b) True/False: This type of analysis is effective in detecting and measuring organic pollutants.

Expected Answer: a) Gas Chromatography Mass Spectrometry b) True

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36. (2.00 pts) How does salinity affect conductivity in a body of water? (include a direction of change and why this is true)

Expected Answer: Increased salinity increases conductivity. Dissolved salts and other ions (inorganic stuff) are charged and are responsible for this.

Congratulation! If you have any feedback, please email to leijianghome@gmail.com. This test is co-written with Selina Zou.