WUCT: Chemistry of Forensics Sample Question

1. You've arrived at the scene of a robbery. Last night, someone broke into the pizzeria and took all the money from the safe. Unfortunately, the owner of the pizzeria forgot to replace her old security cameras, so there was no footage recovered of the suspect. Investigating the scene of the crime, you must use your knowledge of chemistry to get some leads and find the culprit. As you enter the restaurant, you notice a trail of an unknown substance leading from the point of entry to the safe in the back of the restaurant. You take a sample of the mysterious powder and send it to the lab for some tests to determine its identity.

    a. Paper chromatography is a common method of determining the identity of an unknown substance. To perform paper chromatography, an unknown sample is spotted onto a slip of chromatography paper along with known substances, and one end is placed in an organic solvent.

        i. Substances that dissolve better in the chosen solvent will move further up the chromatography paper with the solvent front. If the chosen solvent is a mixture of ethyl acetate: butanol: acetic acid: water in 80:10:5:5 proportionality, what kinds of compounds will travel farthest on the chromatography paper?

        Since the solvent is very polar, polar substances will travel further on the chromatography paper.

        ii. Rank the following substances by how they move on chromatography paper from farthest to the shortest distance: sucrose, graphite, and copper (II) sulfate.

        Copper (II) Sulfate, Sucrose, Graphite

        iii. This is a simplified example to explain the concept of paper chromatography, but in the real world, investigators may already have an idea of what substances they find are. Why can chromatography still be useful in these cases?

        Chromatography can be used to compare an unknown sample to a known standard to confirm the identity of a compound based on physical properties.

b. Next, you find a glass sitting on the counter that the owner alleges was not left out when she closed up the night before. Thinking that the culprit may have used this glass to get a drink from the soda fountain, you pull out your UV light to check for DNA. UV lights often use rechargeable lithium ion batteries for power. Here are two half reactions for a lithium cobalt oxide battery:

$$Li_xC_6 \rightarrow xLi^+ + xe^- + C_6$$
$$Li_{1-x}CoO_2 + xLi^+ + xe^- \rightarrow LiCoO_2$$

i. Write the overall net reaction that occurs.

$$LiCoO_2 + C_6 \rightleftarrows Li_xC_6 + Li_{1-x}CoO_2$$

ii. Identify which half reaction belongs to anode and which half reaction belongs to the anode.

$Li_{1-x}CoO_2 + xLi^+ + xe^- \rightarrow LiCoO_2$ is the cathode
$LiC_6 \rightarrow xLi^+ + xe^- + C_6$ is the anode

iii. Looking at only the reduction potentials of lithium and cobalt, is this reaction spontaneous? Show calculations to find this number in terms of Gibb's free energy.

$$E^o_{cell} = E^o_{red} + E^o_{ox}$$
$E^o_{red} = 1.82$ V $E^o_{ox} = 3.05$ V
$E^o_{cell} = 1.82\ V + 3.05\ V = 4.87\ V$

Yes, since the cell potential is positive, this reaction is spontaneous.

c. Saliva contains many enzymes, like α-amylase, which contain many aromatic amino acids that fluoresce under UV light like tryptophan.

i. Just looking at the glass, you can't tell there is anything on the rim. Why might you need to use a UV light to detect the presence of saliva?

The amino acids present in saliva will not fluoresce unless excited by the UV light, so it is not visible to the naked eye.

ii. Tryptophan when excited releases a photon with a wavelength of 350 nm. What is the energy of this photon?

$$E = \frac{h * c}{\lambda} = \frac{(6.626x10^{-34}Js)(\frac{3.0x10^8 m}{s})}{(3.50x10^{-7}m)} = 5.68 \cdot 10^{-19}$$

iii. If tryptophan is excited by an energy of $7.83x10^{-19}$ J, what wavelength of light is needed to excite it in the first place?

$$\lambda = \frac{h * c}{E} = \frac{(6.626x10^{-34}Js)(\frac{3.0x10^8 m}{s})}{(7.83x10^{-19}J)} = 254\ nm$$

d. You finally make your way back to the safe. The owner has told you that she is the only one who ever accesses the safe, so you decide to search for fingerprints that may not belong to A common method for revealing fingerprints is dusting. Fingerprints are composed of oils and sweat left behind when we touch things. Some black powders used for fingerprinting use graphite and charcoal.

   i. What properties make these compounds good for fingerprint dusting?

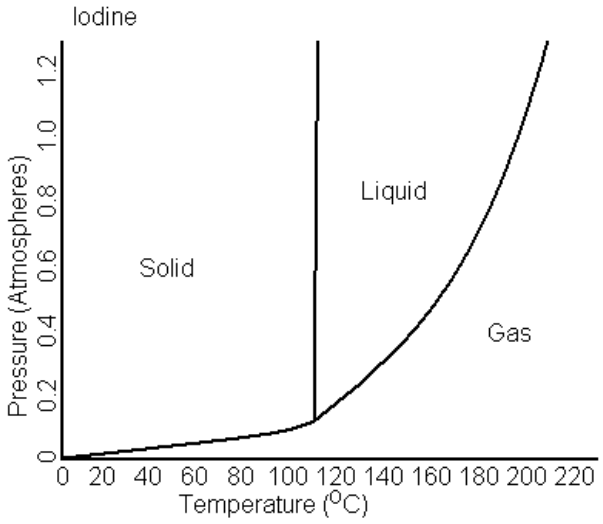
Graphite and charcoal are composed of carbon and are mostly nonpolar, so they adhere well to the nonpolar and oily nature of residue left by human hands.

   ii. Aluminum powder is another dust frequently used when searching for prints. Aluminum powder is magnetic. Why might this property be important when dusting for fingerprints?

Aluminum powder is magnetic and can be brushed gently on fingerprints with less risk of damaging or denaturing them.

e. Another technique for finding fingerprints on porous and non-porous surfaces like paper and carboard is iodine fuming.

   i. According to the following state diagram of Iodine, what state would you expect to find this element at standard temperature and pressure?



Solid

   ii. Iodine fuming is performed by placing the sample in a closed container with solid iodine. The oils from the prints are quenched with iodine vapor to produce a temporary stain. By what process is the container saturated with iodine vapor?

Sublimation