Name: ______________________ Student Number: ____________________ Tutorial Group Number: T________

SHORT ANSWER QUESTIONS: Answers can be written in pen or pencil. Be sure to show your work.

Q1: /13	Q2: /13	Total: /26

1. (13 marks)

(a) [5] Light hits a silver metal surface and the velocity of the ejected electron is 2.52×10^5 m/s. The binding energy of silver is $E_b = 7.58 \times 10^{-19}$ J.

i. Calculate the threshold frequency.

ii. What is the wavelength in nm of the incident light on the silver surface?

$$E_b = 7.58 \times 10^{-19}\ \mathrm{J} = h\upsilon = (6.626 \times 10^{-34}\ Js)\upsilon$$

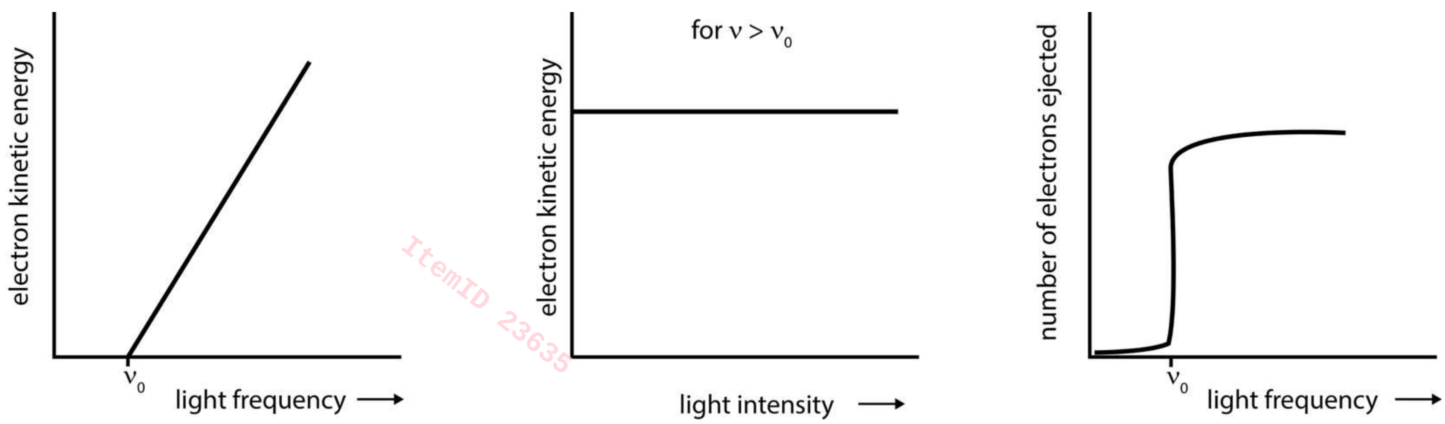
$$\upsilon = 1.14 \times 10^{15}\ \mathrm{Hz}$$

$$h\upsilon = h\frac{c}{\lambda} = E_b + E_k = E_b + \frac{mv^2}{2}$$

$$(6.626 \times 10^{-34}\ Js)\frac{\left(3.0 \times 10^8 \frac{m}{s}\right)}{\lambda} = 7.58 \times 10^{-19}\ \mathrm{J} + \frac{(9.109 \times 10^{-31}\ kg)\left(2.52 \times 10^5 \frac{m}{s}\right)^2}{2}$$

$$\lambda = 253\ nm$$

(b) [3] Consider the photoelectric effect, where photons of frequency ***v*** strike a metal surface for which the frequency corresponding to the binding energy of that metal is denoted by ***v₀***. Sketch the relationships on the three graphs below. Hint: Carefully consider the labels on the axes.



(c) [5] Silver crystallizes in a closest cubic packing structure with a unit cell edge length of 4.09×10^{-8} cm.

i. Calculate the density of silver (g/cm^3).

ii. What is the radius of the silver atom in pm?

$$density = \frac{4\ atoms\ \times 107.87\ g/mol}{(4.09 \times 10^{-8} cm)^3\ (6.02 \times 10^{23} atoms/mol)} = 10.5\ g/cm^3$$

$$\sqrt{2}a = 4r$$

$$\sqrt{2}\,(4.09 \times 10^{-8} cm) = 4\,r$$

$$r = 1.45 \times 10^{-8} cm = 145\ pm$$

2. (13 marks)

(a) [4] 8.660 g of an unknown divalent cation chloride salt (XCl_2) is dissolved in 100.0 mL of water. The freezing point of the solution is – 4.354 °C. What is the identity of the cation? The freezing point depression constant for water is 1.86 °C kg mol^{-1} and the density of water is 1.000 g/mL.

$\Delta T = - K_f\, m\, i$

$m = \Delta T / K_f\, i = -(-4.354\ °C) / ((1.86\ °C\ kg\ mol^{-1})(3)) = 0.7803\ mol / kg$

n_{XCl2} = (0.7803 mol / kg) (1 kg / 1000 g) (1.0 g/mL) (100 mL) = 0.07803 moles

MW: 8.66 g / 0.07803moles = 110.98 g/mol

Identity of the cation: 110.98 – 2(35.45) = 40.08, cation is calcium

(b) A solution is made with 10.5 g of glucose ($C_6H_{12}O_6$, MW: 180.16), 100 mL of water and 100 mL of isopropanol (C_3H_8O, MW: 60.10 g/mol). The temperature of the solution is 25 °C.

i. [1] How do you expect the addition of glucose to affect the vapour pressure of the solution?

The glucose will decrease the vapour pressure of the solution.

ii. [4] What is the mole fraction (X) of isopropanol in the solution? The density of isopropanol is 0.786 g/mL and the density of water is 1.000 g/mL.

Moles isopropanol: 100 mL (0.786 g/mL) / (60.10 g/mol) = 1.308 mol

Moles water: 100 mL (1.000 g/mL) / (18.02 g/mol) = 5.549 mol

Moles glucose: 10.5 g / (180.16 g/mol) = 0.05828 mol

$X_{isopropanol}$ = 1.308 mol / (1.308 mol + 5.549 mol + 0.05828 mol) = 0.189

iii. [4] What is the mole fraction (X) of isopropanol in the gas phase above the solution? At 25 °C the vapour pressure of pure isopropanol is 0.0579 atm and that of pure water is 0.0313 atm.

$P_{iso(solution)} = X_{isopropanol}\, P_{iso(pure)}$ = (0.189) (0.0579 atm) = 0.0109 atm

$P_{wat(solution)} = X_{water}\, P_{wat(pure)}$

= (5.534 mol / (1.308 mol + 5.549 mol + 0.05828 mol))(0.0313 atm) = 0.0251 atm

$X_{isopropanol(gas)} = P_{iso(solution)} / P_{total}$ = (0.0109 atm) / (0.0109 atm + 0.0251 atm) = 0.304