Problem Set 1
Date: 12 August 2019

1. You are in a Star Trek Spaceship Voyager in which you discover an universe with quite different physical laws from those with which we are familiar. Investigating the chemical elements in the alternative universe, you discover these properties:

Symbol	Atomic Weight	State	Electrical Conductivity	Reactivity
Ai	13.90	Gas	Very low	Very low
Bc	11.13	Soft, low-melting solid	High	Very high
Bh	1.42	Gas	Very low	Very low
Dr	30.27	Hard, brittle solid	Semiconductor	Medium
Dt	8.28	Hard, high melting solid	Very high	High
Fn	35.74	Soft, low-melting solid	High	Very high
Fq	32.45	Hard, high-melting solid	Very high	High
Ik	4.82	Diatomic gas	Very low	Very high
On	20.33	Soft, low-melting solid	High	Very high
Sk	16.89	Hard, brittle solid	Semiconductor	Medium
Uc	6.14	Hard, brittle solid	Very low	Medium low
Ye	15.23	Diatomic, volatile* liquid	Very low	Very high
Zw	28.11	Diatomic, volatile solid	Very low	Very high

*Volatile = easily vaporized

A. Arrange these elements into a periodic table. [NOTE: All elements in the first row have been identified. All periods, if complete, would contain the same number of elements.]

B. If a new element, E, with atomic weight 23.1, were discovered, what would its properties be?

C. Are there any other elements that have not yet been discovered? If so, what would their properties be?

2. The German Physicist observed a periodicity in the physical properties of the elements at about the same time as Mendeleev was working on their chemical properties. Some of the Meyer's observation can be reproduced by the molar volume for the solid element as a function of atomic number. Calculate the molar volumes of the element Li to K from

the densities of the elements provided below. Plot you results as a function of the atomic number and describe any variations that you observe.

Element	Density (gm/cm^{-3})
Li	0.53
Be	1.85
B	2.47
C	2.27
N	0.88
O	1.14
F	1.11
Ne	1.21
Na	0.97
Mg	1.74
Al	2.70
Si	2.33
P	1.82
S	2.09
Cl	1.66
Ar	1.66
K	0.86

3. A journalist is writing an article about IYPT2019 in a leading national newspaper. She asks you to write in about 50 words the contribution of Mendeleev in putting together the periodic table. Write this 50-word article which would be read by the readers of this newspaper.

4. An IISER student recently had a busy day. Each of the student activities that day (reading, having dental X-ray, making popcorn in a microwave oven and taking food from a serving table heated with an infrared lamp) involved radiation from different part of the electromagnetic spectrum. Complete the following table and match each type of radiation to appropriate event.

Frequency	Wavelength	Energy of photon	Event
3.18 X 10^{14} Hz			
		3.3 X 10^{-19} J	
300 MHz			
	2.5 nm		

5. The root mean square speed of an O_2 molecule at 21°C is 479 m/s. Calculate the de Broglie wavelength for an O_2 molecule travelling at this speed. How does this

wavelength compare with the approximate length of this molecule, which is about 242 pm. (For this comparison, state the wavelength as a percentage of molecular length)

6. A single photon of UV light has enough energy to mutate human DNA.

(a) Calculate the wavelength (in nm) of a UV photon with a per mol energy of 4,990 kJ. Provide your answer with two significant figures.

(b) Calculate the minimum integer number of 500.0- nm photons that would be required to add up to or exceed the same total energy as a single UV photon from part (a).

(c) Briefly explain the following: Irradiation of a strand of DNA with 25 photons of 500-nm green light will not result in DNA mutation.