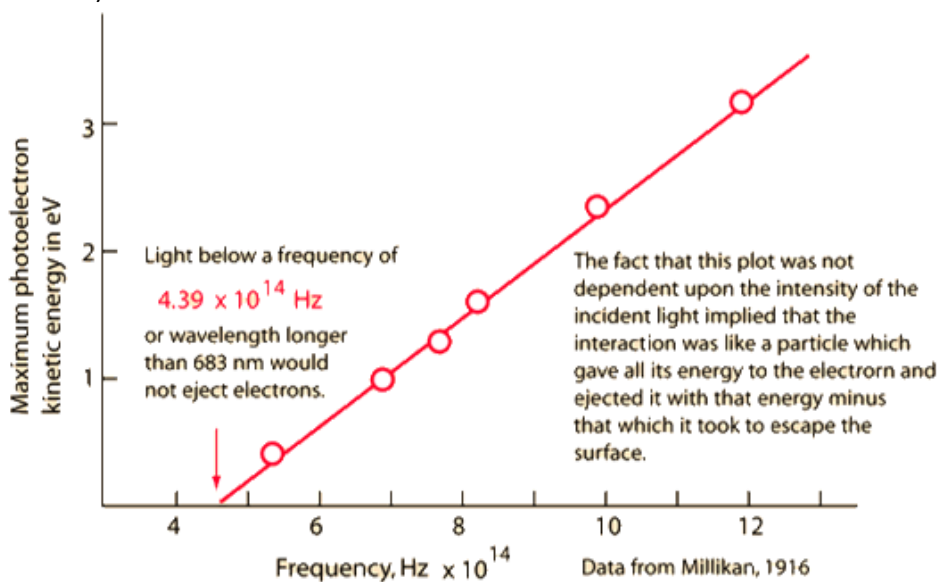


GET1024
Radiation – Scientific Understanding and Public Perception
Term Test 1
(1 hour)

*This test paper contains **24** questions. It comprises **seven** printed pages. Answer all questions by shading the best answer in the Answer Sheet. No marks will be deducted for wrong answer. All questions carry equal weightage.*

- (1) In the light of our current knowledge of atoms and nuclei, some of the following statements of Dalton's atomic theory are only partially correct or even not correct. Which of the following statements is clearly wrong, and not even partially correct?
- a. Elements are made of extremely small particles called atoms.
 - b. Atoms of a given element are identical in size, mass and other properties; atoms of different elements differ in size, mass and other properties.
 - c. Atoms cannot be subdivided, created, or destroyed.
 - d. Atoms of different elements combine in simple whole-number ratios to form chemical compounds.
 - e. In chemical reactions, atoms are combined, separated, or rearranged.
- (2) Burning graphite in one litre of oxygen (O_2) produces 1.1 litres of a mixture of carbon dioxide (CO_2) and carbon monoxide (CO). By Avogadro's hypothesis, in the mixture there are:
- a. 0.6 litre of CO_2 and 0.5 litres of CO
 - b. 0.7 litre of CO_2 and 0.4 litres of CO
 - c. 0.8 litre of CO_2 and 0.3 litres of CO
 - d. 0.9 litre of CO_2 and 0.2 litres of CO
 - e. 1 litre of CO_2 and 0.1 litres of CO
- (3) Neutrino was once believed to have zero rest mass and to move at the speed of light. Recent evidence indicates that neutrino:
- a. Has zero rest mass and moves at a speed slower than the speed of light
 - b. Has zero rest mass and moves at a speed faster than the speed of light
 - c. Has a small rest mass and moves at the speed of light
 - d. Has a small rest mass and moves at a speed faster than the speed of light
 - e. Has a small rest mass and moves at a speed slower than the speed of light

- (4) A photon of frequency ν and wavelength λ has energy $E = h\nu$ and momentum $p = h/\lambda$, where the Planck constant $h = 6.626 \times 10^{-34}$ Js. From the experimental results presented below, what is the energy required for an electron to escape from the illuminated surface? (Note: electron charge is 1.602×10^{-19} C)



- 0.005 eV
 - 1.8 eV
 - 3.1 keV
 - 0.511 MeV
 - 24 GeV
- (5) The half-lives of U-235 and U-238 are 0.7 billion years and 4.46 billion years respectively. Natural uranium currently consists of 99.3% U-238 and 0.7% U-235. The ratio of U-238 to U-235 2 billion years ago should be about:
- 70% - 30%
 - 82% - 18%
 - 96% - 4%
 - 99.3% - 0.7%
 - 99.9% - 0.1%
- (6) Radon has many isotopes, which of the five in the list below belongs to the Uranium ($4n+2$) decay chain?
- Rn-211
 - Rn-219
 - Rn-220
 - Rn-222
 - Rn-224

- (7) One mode of fission of U-235 produces Xe-140 and Sr-94. It is known that among the isotopes of Sr, Sr-86, Sr-87 and Sr-88 are stable. Sr-94 therefore
- Has too many protons and will undergo electron capture decay
 - Has too many protons and will undergo β^+ decay
 - Is too large and will undergo alpha decay
 - Has too many neutrons and will undergo β^- decay
 - Has too many neutrons and will undergo fission decay
- (8) The Sun generates its energy by a process by which 4 protons are fused into a helium-4 nucleus. The proton mass is $938.272 \text{ MeV}/c^2$, the electron mass is $0.511 \text{ MeV}/c^2$, and the mass of a helium-4 atom is $3728.400 \text{ MeV}/c^2$. The energy released by fusing 4 protons into a helium-4 nucleus is then about
- $0.25 \text{ MeV}/c^2$
 - $2.5 \text{ MeV}/c^2$
 - $25 \text{ MeV}/c^2$
 - $250 \text{ MeV}/c^2$
 - $2.5 \text{ GeV}/c^2$
- (9) Which of the following would not reduce the dose received when working with radioactive sources?
- Increase the distance to the source
 - Reduce the time in contact with the source
 - Add shield between source and users
 - Use a source with lower activity
 - Replace an older source with a newly acquired one
- (10) It was suspected that a man was accidentally exposed to a radiation source. Which of the following information would not help in determining the amount of radiation that he was exposed to?
- The identity of the radioactive element.
 - The distance of the radioactive source from the man.
 - The mass of the radioactive element present.
 - The length of the exposure.
 - All of the above information would be helpful.

- (11) A radioactive chemical was spilled into a forested area. A scientist was tasked with quickly identifying the chemical which was spilled. Which instrument would be the most practical for this purpose?
- A Geiger Muller counter.
 - A personal dosimeter.
 - An in situ gamma spectrometer.
 - An alpha spectrometer.
 - A liquid scintillation counter.
- (12) Alpha spectrometry samples preferably should be prepared thin. Which of the reasons below is incorrect?
- Thick samples result in thick peaks.
 - Thin samples result in a shorter analysis time.
 - Thin samples result in a spectrum with better resolution.
 - Alpha particles lose their energy travelling through a thick sample.
 - None of the statements above are incorrect.
- (13) A man drank tea which was poisoned with a radioactive chemical. The waitress who served him the tea, was estimated to have been exposed to an equivalent dose of 10 μSv . Which of the statements below is correct?
- The man's equivalent dose is also about 10 μSv .
 - The man's equivalent dose is much lower than 10 μSv .
 - The man's equivalent dose is much higher than 10 μSv .
 - You can find his exact equivalent dose if you measure his exposure in a full body gamma spectrometer.
 - None of the statements above are correct.
- (14) Which of the following are the two radioactive isotopes in our bodies that have the highest activities?
- Iodine-131 and Cesium-137
 - Tritium and Cesium-137
 - Carbon-14 and Nitrogen-15
 - Potassium-40 and Iodine-131
 - Carbon-14 and Potassium-40

- (15) Some old cameras manufactured in 1960s are radioactive due to the presence of
- Thorium
 - Uranium
 - Cesium
 - Iodine
 - Tritium
- (16) Which of the following statements are true regarding factors that affect the extent of biological responses to radiation exposure:
- Cells with higher mitotic activity are more radiosensitive. This is why the bone marrow and reproductive organs are the most susceptible
 - Alpha particles are less hazardous when the exposure is external compared to when the exposure is internal, because it has a low penetration depth compared to other types of radiation
 - Younger cells have fewer anti-oxidant mechanisms and are therefore more susceptible to reactive oxygen species generated by radiation exposure
- (i) only
 - (ii) only
 - (iii) only
 - (i) and (ii) only
 - (i), (ii) and (iii)
- (17) Which of the following statement is true:
- Deterministic effects occur once a threshold of exposure has been reached, and the severity decreases as dose increases
 - Deterministic effects are generally a result of accumulation of mutations in the cell
 - The severity of stochastic effects are not dose related
 - Stochastic effects are generally a result of cell death
 - Deterministic effects are believed to follow a linear no-threshold model
- (18) Among the types of power reactors below, which are the most common ones?
- High temperature gas-cooled reactors
 - Boling water reactors
 - Pressurized water reactors
 - Fast breeder reactor
 - Small modular reactors

- (19) Moderators are needed in light water reactors to
- Reduce the temperature of the core
 - Circulate the water in the primary circuit
 - Maintain the pressure in the vessel
 - Shut down the reactor during accidents
 - Slow down the neutrons
- (20) Which of the following is the greatest risk of severe accidents in light water reactors?
- Inability to remove the decay heat of fission products
 - Inability to shut down the reactor during accidents
 - Inability to control the pressure in the reactor vessel.
 - Inability to circulate water in the primary circuit.
 - Inability to control the reactivity in the core.
- (21) Which of the following is true regarding the advantages and disadvantages of the various types of studies on biological effects of radiation?
- Epidemiological studies can be susceptible to many confounding factors that may make the correlation between radiation exposure and biological effects difficult
 - The effects observed in mice can be directly correlated to humans as they have similar radiosensitivities
 - Studying the biological effects in cells *ex vivo* will reflect the whole body physiological response to radiation
 - Whole body irradiation studies cannot be conducted using animals
 - Plants cannot be used to study biological effects of radiation as they are not affected by radiation exposure
- (22) Which of the following could potentially serve as a radioprotectant to be administered in a case of acute external exposure of 2 Gy:
- A compound which prevents the radioactive substance from binding to target organs
 - A compound which halts blood cell production in the bone marrow
 - A skin cell transplant
 - A compound which halts DNA repair
 - A free radical scavenger

The following table was extracted from the Material Safety Data Sheet of radium-126. Use the information given to answer Questions 23 and 24.

Principle Emissions	E ^{Max} (keV)	E ^{eff} (keV)	Dose Rate (μSv/h/GBq at 1m)	Shielding Required
Beta* (β)	-	-	-	-
Gamma (γ) / X-Rays	186 (32.8%)	-	3.3 ^a	HVL Lead: 0.04 cm
Alpha (α)	4,785 (94.6%)	-	-	-
Neutron (n)	-	-	-	-

- (23) A student performed an experiment with a 1 μCi source for about 2 hours. Assuming that the average distance between him and the source was 30 cm, what was the additional dose due to this experiment? You may neglect the effect of alpha particles for this question.
- 3 mSv
 - 30 μSv
 - 0.3 μSv
 - 3 nSv
 - 0.03 nSv
- (24) A GM detector read 5,000 counts per minute (cpm) when a radium source was placed 40 cm from it. When a 2-mm lead shield was placed in front of a GM detector, approximate what value would the detector indicate?
- 5,000 cpm
 - 1,000 cpm
 - 160 cpm
 - 30 cpm
 - ≈ 0 cpm