Answers to Review Questions for Atomic Theory Quiz #1

Multiple Choice Questions:

1. c	7. a	13. c	19. a	25. b	31. b	37. a	43. d
2. d	8. c	14. c	20. c	26. d	32. c	38. d	44. b
3. b	9. a	15. b	21. c	27. b	33. a	39. b	45. a
4. b	10. c	16. c	22. d	28. c	34. c	40. a	46. a
5. d	11. b	17. d	23. d	29. a	35. b	41. a	47. a
6. a	12. c	18. b	24. b	30. b	36. c	42. d	48. c

Written Answer Questions:

1. Refer to your notes for definitions.

2. What are the three types of sub-atomic particles? Describe each particle in terms of its charge, mass and location in the atom.

	Protons	**Neutrons**	**Electrons**
Mass	1 amu	1 amu	negligible
Charge	1+	0 (neutral)	1-
Location	nucleus	nucleus	space around nucleus

3. Which of the following are reported on the Periodic Table: atomic number, mass number, actual atomic mass, average atomic mass, percent abundance?
   - atomic number and average atomic mass are the only two which are reported on the Periodic Table

4. Clearly distinguish between average atomic mass and mass number. In what three ways do they differ?

Average Atomic Mass	**Mass Number**
<u>Definition</u>: the weighted average mass of all of the isotopes of an element	**<u>Definition</u>**: the number of protons plus the number of neutrons in the nucleus of an atom
• units are amu	• it has no units
• it is reported on the Periodic Table	• it is not reported on the Periodic Table
• it is an actual average mass	• it is a counted value, not a mass
• it can have a decimal value	• it is always a whole number

5. The average atomic mass of calcium is 40.08 u. What is probably its most abundant isotope?
   - Ca-40 is probably the most common isotope (the average atomic mass is ***usually*** close to the mass number of the most common isotope)

6. What are two possible isotopes of nickel? Ni – 58, Ni – 59, Ni – 60 (any of these are possible)

7. How many neutrons are found in one atom of each: ${}_{27}^{60}\text{Co}$, ${}_{38}^{90}\text{Sr}$, ${}_{47}^{108}\text{Ag}$, ${}_{82}^{207}\text{Pb}$, ${}_{85}^{210}\text{At}$, ${}_{92}^{238}\text{U}$?

   ${}_{27}^{60}\text{Co}$ has (60 – 27) = 33 neutrons

   ${}_{38}^{90}\text{Sr}$ has (90 – 38) = 52 neutrons

   ${}_{47}^{108}\text{Ag}$ has (108 - 47) = 61 neutrons

   ${}_{82}^{207}\text{Pb}$ has (207 - 82) = 125 neutrons

   ${}_{85}^{210}\text{At}$ has (210 - 85) = 125 neutrons

   ${}_{92}^{238}\text{U}$ has (238 - 92) = 146 neutrons

8. What is meant by the expressions "carbon-14" and "silver-108"?
   - carbon – 14 refers to the isotope of carbon with a mass number of 14 (it has 6 protons and 8 neutrons)
   - silver – 108 refers to the isotope of silver with a mass number of 108 (47 protons and 61 neutrons)

9. How many electrons, protons and neutrons are in a neutral atom which has:
   a) atomic number of 38 and the mass number of 90?
   - this is strontium: it has 38 protons, 38 electrons in a neutral atom and (90 – 38) or 52 neutrons

   b) atomic number of 82 and the mass number of 207?
   - this is lead: it has 82 protons, 82 electrons in a neutral atom, and (207 – 82) or 125 neutrons

10. Natural neon consists of a mixture of three isotopes: 90.92 % neon-20, atomic mass 19.9924 u; 0.257 % neon-21, atomic mass 20.9930 u; and 8.82% neon-22, atomic mass 21.9914 u.
    a) Without doing any calculations, estimate the approximate average atomic mass of neon. about 20 amu
    b) Calculate the average atomic mass of neon.

AAM = (% abundance of Ne – 20 x mass of Ne – 20) +
(% abundance of Ne – 21 x mass of Ne – 21) +
(% abundance of Ne – 22 x mass of Ne – 22)

= (0.9092 x 19.9924 u) + (0.00257 x 20.9930 u) + (0.0882 x 21.9914 u)
= 18.1771 u + 0.05395 u + 1.19396 u
= 20.17 u (report two decimal places)

11. Natural potassium consists of 93.1 % potassium-39 (atomic mass 38.964 u) and 6.9 % potassium-41 (atomic mass 40.962 u). Estimate and then calculate the average atomic mass of natural potassium.
    - the average atomic mass of potassium should be close to the mass number of the most common isotope, so it should be about 39 amu

AAM = (% abundance of K – 39 x mass of K - 39) +
(% abundance of K - 41 x mass of K – 41)

= (0.931 x 38.964 u) + (0.069 x 40.962 u)
= 36.275 u + 2.826 u
= 39.10 u (2 decimal places)

12. What are the four signs (indications) that a chemical change has taken place?
    - a colour change
    - a gas is produced (bubbles or "smoke"; the gas may have a new odour)
    - a precipitate forms
    - energy is given off or absorbed in the form of heat, light, sound or electricity

13. Describe 5 physical properties of the carbon (graphite) in your pencil.
    - opaque
    - solid at SATP
    - black coloured
    - brittle
    - melting point 3825 K
    - dull (non-lustrous)
    - odourless
    - non-magnetic
    - does not dissolve in water
    - density 2.26 g/cm^3

***remember to include units for melting point, boiling point and density**

14. Outline the contributions of Dalton, Thomson, Rutherford and Bohr to the present understanding of atomic structure. For each, describe their experiment and model of the atom.

Dalton:

- revived the atomic theory and got science back on track
- stated that all matter is made of atoms
- he said that all atoms are invisible and indivisible (the billiard ball model)
- he believed that atoms of different elements had different sizes or shapes
- during a chemical reaction, atoms are rearranged to form new substances, but atoms can not be created nor destroyed
- he based his theory on the Law of Conservation of Mass and Law of Constant Composition
- he was incorrect in that he believed all atoms of an element to be identical (we now know that there are isotopes) and that atoms couldn't be created or destroyed (we now know about nuclear reactions)

Thomson:

- passed a high voltage electric current through a cathode ray tube (Crooke's tube) and observed that the metal electrode gave off a green beam of "light". This beam could be attracted and deflected by a magnet, so it wasn't light, but a stream of charged particles which he named electrons and assigned a negative charge
- it didn't matter what type of metal Thomson used for the electrodes, the beam of particles was always the same. Thomson interpreted this to mean that electrons were a fundamental part of all matter
- Thomson reasoned that if the electrodes were initially neutral, but gave off negative particles, then the atom must also contain positive charges
- he believed that the electrons were embedded in a positive solid matrix, the way that raisins stick in a raisin bun

Rutherford:

- shot alpha particles (helium nuclei) through a very thin piece of gold foil. The gold foil was surrounded by a fluorescent screen, which gave off a little flash of light so he could see where the alpha particles hit the screen. Most of the alpha particles passed straight through the gold foil, but some were deflected and some bounced straight back
- because most of the alpha particles passed straight through the gold foil, Rutherford believed that most of an atom must be empty space. Because some of the positively charged alpha particles were deflected, there must be a region of positive charge in the atom. Because some alpha particles bounced back, he interpreted this to mean that atoms must contain a very solid, dense, positively charged core (the nucleus)
- altogether, he concluded that atoms contain a solid, dense positively charged core which he called the nucleus and that the electrons were found in the space around the nucleus in a random electron cloud
- he discovered the atomic nucleus and that atoms are mostly empty space

Bohr:

- passed an electric current through a glass tube containing hydrogen gas. He studied the light that the hydrogen gave off (its atomic emission or bright line spectrum) using a spectroscope
- if Rutherford's random electron cloud model of the atom was correct, Bohr would have seen a continuous spectrum (a rainbow) that contained all of the colours of light
- instead, Bohr saw only four distinct bands of colour, separated by black (no light) regions
- Bohr interpreted this to mean that the electrons could only be certain, discrete distances from the nucleus
- he proposed the planetary model of the atom, in which the electrons are orbiting the nucleus in fixed predictable orbits that are discrete distances from the nucleus

15. Refer back to the note "In Search for a Model for Matter: 2400 Years of Atomic Theory". Two of the statements made by Dalton in his atomic model are incorrect. Which two statements are incorrect, and why?

- Dalton believed that all atoms of an element are identical. This is untrue. Most atoms have different isotopes. That is, these atoms have the same number of protons, but different numbers of neutrons.

- Dalton also believed that atoms were the smallest particle of matter, and that atoms could not be created or destroyed. We now know that there are sub-atomic particles: protons, neutrons and electrons, and these can be separated or joined during nuclear reactions

16. Three experiments or pieces of scientific equipment were key to our present understanding of atomic structure. For each of the following, outline the major discovery that it contributed to:

a) cathode ray tubes (also called gas discharge tubes or Crooke's tube): Thomson used it to discover the electron and that the electron is negatively charged

b) Rutherford's gold foil experiment: Rutherford shot alpha particles through gold foil and discovered the atomic nucleus. He learned that all atoms have a dense, positively charged core and that the electrons are found in the space around the nucleus

c) the bright line spectrum for the hydrogen atom: Bohr discovered that electrons can only be certain, discrete distances from the nucleus. The electrons orbit the nucleus in fixed predictable orbits rather that circling it randomly in an electron cloud

17. Explain where the different colours of light come from in the bright line spectrum of an element.
    - when electrons are excited by the addition of energy, they absorb this energy and move out further from the nucleus
    - when the electrons drop back closer to the nucleus, they give off the added energy as light
    - depending on how far the electrons were from the nucleus, they will give off light of different wavelengths (different colours) when they drop back

18. Compare and contrast the models of the atom that were proposed by Thomson and Rutherford.
    - both Thomson and Rutherford's atomic models include the sub-atomic electrons and protons
    - neither of their models included neutrons
    - Thomson's model (the raisin bun) suggested that the atom was a solid sphere, with the electrons embedded in among the positive protons (matrix)
    - Rutherford's model (the electron cloud) suggested that the protons are found only in the dense, solid nucleus of the atom and that electrons are flying in a random electron cloud around the nucleus
    - in Rutherford's model, the atom is mostly empty space and this is where the electrons are found

19. Compare and contrast the models of the atom that were proposed by Rutherford and Bohr.
    - both Rutherford and Bohr's atomic models include electrons flying in the space around a positive nucleus
    - neither of their models included neutrons
    - Rutherford's model (the electron cloud) suggested that the electrons are flying in a random electron cloud around the nucleus
    - Bohr's model proposes that the electrons are orbiting the nucleus in fixed, defined paths

20. Write the balanced nuclear equations for the following nuclear reactions:
    a) polonium-209 undergoes alpha decay

$$^{209}_{84}\mathbf{Po} \longrightarrow {}^{205}_{82}\mathbf{Pb} + {}^{4}_{2}\mathbf{He}^{2+}$$

b) carbon-14 undergoes beta decay (this is the nuclear reaction that is used for "carbon dating")

$$^{14}_{6}\mathbf{C} \longrightarrow {}^{14}_{7}\mathbf{N} + {}^{0}_{1-}\mathbf{e}$$

c) Sr-90 undergoes beta decay (Sr-90 is a by-product of some nuclear reactors. It replaces calcium in mammals' bones. When Sr-90 decays, it can damage bone tissue and lead to cancer.)

$$^{90}_{38}\mathbf{Sr} \longrightarrow {}^{90}_{39}\mathbf{Y} + {}^{0}_{1-}\mathbf{e}$$

d) uranium-234 undergoes alpha decay

$$^{234}_{92}\mathbf{U} \longrightarrow {}^{230}_{90}\mathbf{Th} + {}^{4}_{2}\mathbf{He}^{2+}$$

21. Nuclear power has been suggested as a solution to our current environmental problems with global warming and acid rain. What are two advantages of nuclear power? Two disadvantages?

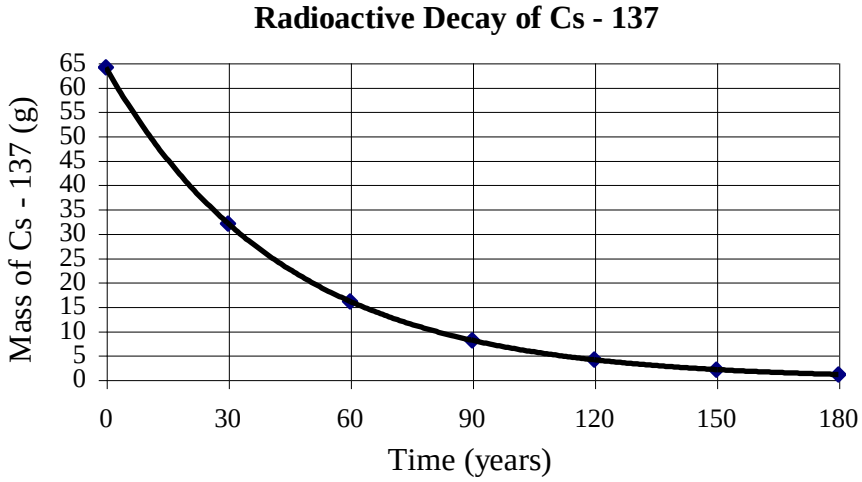
Advantages of nuclear power:

- does not produce green house gases
- does not contribute to acid rain
- does not produce toxic gases (SO_2 or mercury oxide)
- you can build the nuclear reactors close to where the energy is needed

Disadvantages of nuclear power:

- ground water around uranium mines can be contaminated from uranium "tailings" (mine refuse)
- long term storage of radioactive wastes is a huge problem
- heated waste water can cause thermal pollution where it is released (most fish require cold water)
- there is always the risk of accidents at a nuclear power facility, such as melt down

22. The half-life of cesium-137 is 30 a (years). Begin with a 64 g sample of Cs-137, and draw a graph showing the rate of radioactive decay of cesium. How much Cs-137 will remain after 120 years?



- 120 years represents 4 half-lives. After 120 years there will be 4 grams of Cs – 137 remaining.

23. Does a shorter half-life indicate that an isotope is more stable or less stable?
    - a shorter half-life means that the substance breaks down more quickly, which means that the substance is **<u>less</u>** stable

24. Classify the following as elements or compounds. Identify the number and type of atom(s) in one molecule:
    a) $(NH_4)_2Cr_2O_7$ is a compound, contains 2 (N) + 8 (H) + 2 (Cr) + 7 (O) atoms
    b) P_4 is an element, it contains 4 (P) atoms
    c) S_8 is an element, it contains 8 (S) atoms
    d) $Al(C_2H_3O_2)_3$ is a compound, it contains 1 (Al) + 6 (C) + 9 (H) + 6 (O) atoms

25. Classify the following changes as either a chemical (C) or physical (P) change:
    a) iron is heated until it melts and glows red **(P)**
    b) a sausage is roasted over the fire **(C)**
    c) a puddle evapourates in the sun **(P)**
    k) a fluorescent light gives off light **(P)**
    f) the wires in a toaster glow red **(P)**
    g) crystals form in liquid honey **(P)**
    h) when clear, colourless $AgNO_3$ is added to tap water, it turns white and cloudy **(C)**
    i) a "silver" penny turns to "gold" when Mrs. Patterson heats it **(C)**
    j) zinc fizzes when it dissolves in acid **(C)**
    k) flax seeds are ground up in a blender **(P)**
    l) a log decomposes into soil **(C)**
    m) "Koolaid" dissolves in water **(P)**
    n) a solid deodorant "puck" sublimates in a bathroom **(P)**
    o) gel turns solid when hair is "spiked" **(P)**

26. Are the following statements true or false? If a statement is false, be able to explain why it is false.
    a) Atoms can not be created nor destroyed.
        - **False**. Nuclear reactions involving breaking down atomic nuclei.
    b) A beta-particle is really a high speed electron. **True**
    c) A neutron (as far as we know) is a high-speed electron.
        - **False**. A high speed electron is called a beta particle.
    d) Neutrons are released by atoms when they undergo gamma decay.
        - **False**. Gamma radiation releases no particles
    e) Adding more neutrons to an atom's nucleus will make the nucleus more stable.
        - **False**. Too many or too few neutrons will make a nucleus unstable. Adding neutrons will not necessarily increase the stability of a nucleus.
    f) The Alchemists did not make any contribution to modern Science or Chemistry.
        - **False**. They invented many types of scientific equipment that are still used today.
    g) Rutherford discovered the proton.
        - **False**. He discovered the nucleus and that protons are found in the nucleus.
    h) The cathode ray (Crooke's) tube was used to discover that electrons move in fixed orbits around the nucleus.
        - **False**. Cathode ray tubes were used by Thomson to discover the electrons. The bright line spectrum of hydrogen was used to discover that electrons moved in orbits.
    i) James Chadwick discovered the neutron. **True**
    j) All atoms of an element are identical.
        - **False**. Isotopes of the same element have different numbers of neutrons. Ions of the same element have different numbers of electrons.
    k) The number of **<u>neutrons</u>** is equal to the number of protons in a neutral atom.
        - **False**. The number of neutrons has no direct, predictable relationship to the number of protons. Large nuclei have many more neutrons than protons.

Question 26 (cont)

l) The number of electrons always equals the number of protons in an atom.

- **False**. The number of electrons only equals the number of protons in a NEUTRAL atom. In IONS, the number of electrons can be greater than, or less than, the number of protons.

m) An O^{2-} ion and a Mg^{2+} ion have the same number of electrons. **True**. Both have 10 electrons.

n) Neutrons act as "spacers" to help to stabilize the nucleus of an atom. **True**

o) The number and arrangement of an atom's electrons determines the its physical and chemical properties. **True**

27. Indicate whether the following substances are elements or compounds:

a) Uranium ore (U_2O_3) that is used in a CANDU reactor **compound**

b) The gold foil used by Rutherford for his experiment **element**

c) The hydrogen gas (H_2) that Bohr excited during his studies of the hydrogen spectrum **element**

d) The hydrochloric acid used to test the reactivity of metals **compound (HCl)**

e) Pure "heavy" water (deuterium oxide) that is used to control a nuclear reaction **compound (H_2O)**

f) A sample of magnesium ribbon that contains a mixture of Mg-24, Mg-25 and Mg-26 **element**

28. Indicate which of the following observations are qualitative or quantitative. Which of them are **<u>properties</u>**?

a) Pure silver is a good conductor of electricity. **Qualitative property**

b) The mass of the gold is 36 g. **Quantitative, but NOT a property**

c) Chlorine gas has a density of 3.214 g/L. **Quantitative property**

d) Iodine is a solid at SATP. **Qualitative property**

e) The temperature of the mercury is 23 ºC. **Quantitative, but NOT a property**

f) Pure distilled water does not conduct electricity. **Qualitative property**

g) Magnesium metal burns with a bright white flame. **Qualitative property**

h) Silicon is a semi-conductor. **Qualitative property**

i) The volume of pure water is 1.45 L **Quantitative, but NOT a property**

j) Salt (sodium chloride) melts at 1200 ºC. **Quantitative property**

29. Compare the properties of metals and non-metals:

Property	Metal	Non-metal
Does it conduct electricity?	Yes	No
"Usual" state at room temperature?	Solid (except mercury)	Solid, liquid or gas
Is the solid malleable or brittle?	Malleable	Brittle
"Usual" colour	Silver - coloured	Any colour, or colourless
Lustre of the solid?	Shiny	Dull

30. Complete the following chart:

Element	Atomic Number	Number of Protons	Mass Number	Number of Neutrons	Charge	Number of Electrons
Fe	26	26	56	30	3+	23
Co	27	27	58	31	3+	24
Pb	82	82	207	125	1+	81
Si	14	14	28	14	4 -	18
Cd - 112	48	48	112	64	3+	45
Zr	40	40	91	51	2+	38
Rn	86	86	222	136	0	86
Cu	29	29	64	35	1+	28
Cl	17	17	37	20	1-	18
Mg	12	12	26	14	2+	10
Ba	56	56	138	82	2+	54
Cl	17	17	35	18	0	17
Mg - 25	12	12	25	13	0	12

31. From the chart above, identify
a) any isotopes of the same elements: Cl – 35 and Cl – 37; Mg – 25 and Mg - 26
b) any ions of the same elements: Cl – 35 and Cl – 37; Mg – 25 and Mg - 26

32. Complete the following chart that compares the properties of the three types of nuclear radiation:

	α (alpha) particle	**β (beta) particle**	**γ (gamma) radiation**
Another name for this type of particle	Helium nucleus	High speed electron	N/A
The symbol for this particle	$^{4}_{2}He$	$^{0}_{-1}e$	N/A
Approximate speed it moves and amount of energy	slow, low energy	faster, higher energy	extremely fast (moves at the speed of light) and is very high energy
How far will it travel through the air?	1 –2 cm	2 m	unlimited distances
What thickness of material is require to contain it (stop it from penetrating)?	a piece of paper	2 mm of lead	1 m of lead or concrete

33. Iron – 59 is radioactive. Predict five (5) characteristic physical properties of Fe – 59.

Careful answering this question! The fact that Fe-59 is radioactive is a ***nuclear*** property, not a ***physical*** property.

Also, the fact that iron is a metal is not a property. Being a metal is a classification.

But, because iron is a metal, we can predict the following physical properties: it is shiny (lustrous), gray, solid at SATP, malleable, ductile and a good conductor of heat and electricity. We also know that iron is magnetic. From the periodic table, its density is 7.874 g/cm^3, its melting point is 1811 K and its boiling point is 3134 K.