AIRCRAFT TECHNICAL BOOK COMPANY

CAT-A

AVIATION MAINTENANCE TECHNICIAN CERTIFICATION SERIES

PHYSICS

2

COMPLIANT WITH EASA PART 66/147

EASA 2023-989 COMPLIANT

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VERSION	EFFECTIVE DATE	DESCRIPTION OF REVISION(S)
001	2013 12	Module creation and release.
002	2020.02	Minor appearance updates.
002.1	2020.05	Clarified formulas for Buoyant Force (page 2.7) and Vibration (page 2.11).
002.2	2020.05	Corrected formulas for Pendular Movement and Vibration (Submodule 2).
002.3	2022.06	Clarified number of electrons in orbital shells (Submodule 1).
002.4	2022.06	Minor appearance and format updates.
003	2024.08	Regulatory update for EASA 2023-989 compliance.

Module was reorganized based upon the EASA 2023-989 subject criteria.

2.2.1 *Nature and Properties of Solid, Fluid and Gas Matter* - added content.
2.3 *(B) Thermodynamics* - section added.
Other minor adjustments and figure enhancements throughout.
Submodule review questions added.

PHYSICS

TABLE OF CONTENTS

The elements are arrange in a table known as the periodic table. The table groups the elements by periods horizontally and vertically to show similar characteristics of the elements. [**Figure 1-3**]

MOLECULES

Atoms of the same or different elements may bond to form a molecule. When atoms of the same element bond to form a molecule, it will retain the inherent properties of that element. When atoms of different elements bond to form a molecule, the molecule has properties and characteristics completely different than those of each of the individual elements that comprise it. A water molecule, for example, is made up of two hydrogen atoms and one oxygen atom. Water has its own unique properties that are completely different than those of hydrogen or oxygen alone.

ELECTRON CONFIGURATION

Electrons are configured around the nucleus in orderly, concentric rings known as shells. **Figure 1-2** illustrates the basic structure and components of atoms; in this case an Oxygen atom which contains 8 protons and eight neutrons in its nucleus and eight electrons orbiting within two shells.

When atoms bond to form molecules, they share electrons. In most cases, the closest shell to the nucleus can only contain two electrons. If the atom has more than two electrons, those are found in the next orbital shell away from the nucleus. The second shell can only hold eight electrons. If the atom has more than 10 electrons (2 + 8), they orbit a third shell further out from the nucleus which can hold a maximum of 18 electrons. If the atom has more than 28 electrons (2 + 8 + 18) a fourth shell forms which can hold up to 32 electrons, etc. [**Figure 1-4**]

The outer most orbital shell of any atom's electrons is called the valence shell. The number of electrons in the valence shell determines the chemical bonding properties of the material as well as other characteristics such as electrical conductivity. When the valence shell has the maximum number of electrons, it is complete and the electrons tend to be bound strongly to the nucleus. Materials with this characteristic are chemically stable. It takes a large amount of force to move the electrons in this situation from one atom valence shell to that of another. Since the movement of electrons is called electric current, substances with complete valence shells are known as good insulators because they resist the flow of electrons (electricity). [**Figure 1-5**]

In atoms with an incomplete valence shell, that is, those without the maximum number of electrons in their valence shell, the electrons are bound less strongly to the nucleus. The material is disposed to combine with other materials or other identical atoms to fill in the unstable valence configuration and bring the number of electrons in the valence shell to maximum. Molecules are formed this way.

Electrons in incomplete valence shells may also move freely from valence shell to valence shell of different atoms. In this case, these are known as free electrons. As stated, the movement of electrons is known as electric current. When electrons move freely from atom to atom, the substance is known as a conductor. [**Figure 1-6**]

IONS

Ionization is the process by which an atom loses or gains electrons. Dislodging an electron from an atom causes the atom to become positively charged. An atom which has gained an extra number of electrons is negatively charged. When atoms are neutral, the number of positively charged protons and negatively charged electrons are equal.

ISOTOPES

When atoms of the same element have different numbers of neutrons, they are called isotopes. Because of the differing numbers of neutrons, various isotopes of the same element have different masses. Mass is the word for how much matter something has and therefore how much it weighs. [**Figure 1-7**] Isotopes of the same element also have the same number of electrons and the same electronic structure. Because how an atom acts is decided by its electronic structure, isotopes are almost the same chemically, but they are different physically because of their different masses.

Hydrogen, the most common element, has three common isotopes. Its most common isotope with only one proton and no neutrons is called protium (1H). A hydrogen atom with one proton and one neutron (atomic mass of 2) is called deuterium(2H). A hydrogen atom with one proton and two neutrons (atomic mass of 3) is called tritium(3H).

CHEMICAL COMPOUNDS

Materials made up of two or more elements that have chemically bonded are known as compounds. Compounds have properties different than the elements from which they are made. They can only be separated through chemical reaction. Compounds should not be confused with mixtures. Mixtures are atoms and molecules that are physically mixed together but are not chemically bonded. The properties and characteristics of a mixture are closely related or dependent on the properties of the individual constituents. Mixtures can usually be separated by filtering, evaporation or some other mechanical means.

STATES OF MATTER

Matter exists in four common states; solids, liquids, gases and plasma. A state of matter is the physical condition of a substance. Solids, liquids and gases are the primary states of matter of concern for the aviation maintenance professional.

Regardless of the state of matter, the compound(s) from which a substance is made does not change. Atoms and molecules that make up a substance are always in a state of motion due to heat energy in the material. However, the physical state of matter is related to the motion or energy between these particles with solids having the least amount of energy and gases and plasma having the most. [**Figure 1-8**]

SOLIDS

Matter is said to be solid when it has a definite volume and shape. The molecules of a solid are tightly bound to each other. They resist changing shape or volume. They are incompressible and do not contain enough movement of the molecules to permit a physical change of shape.

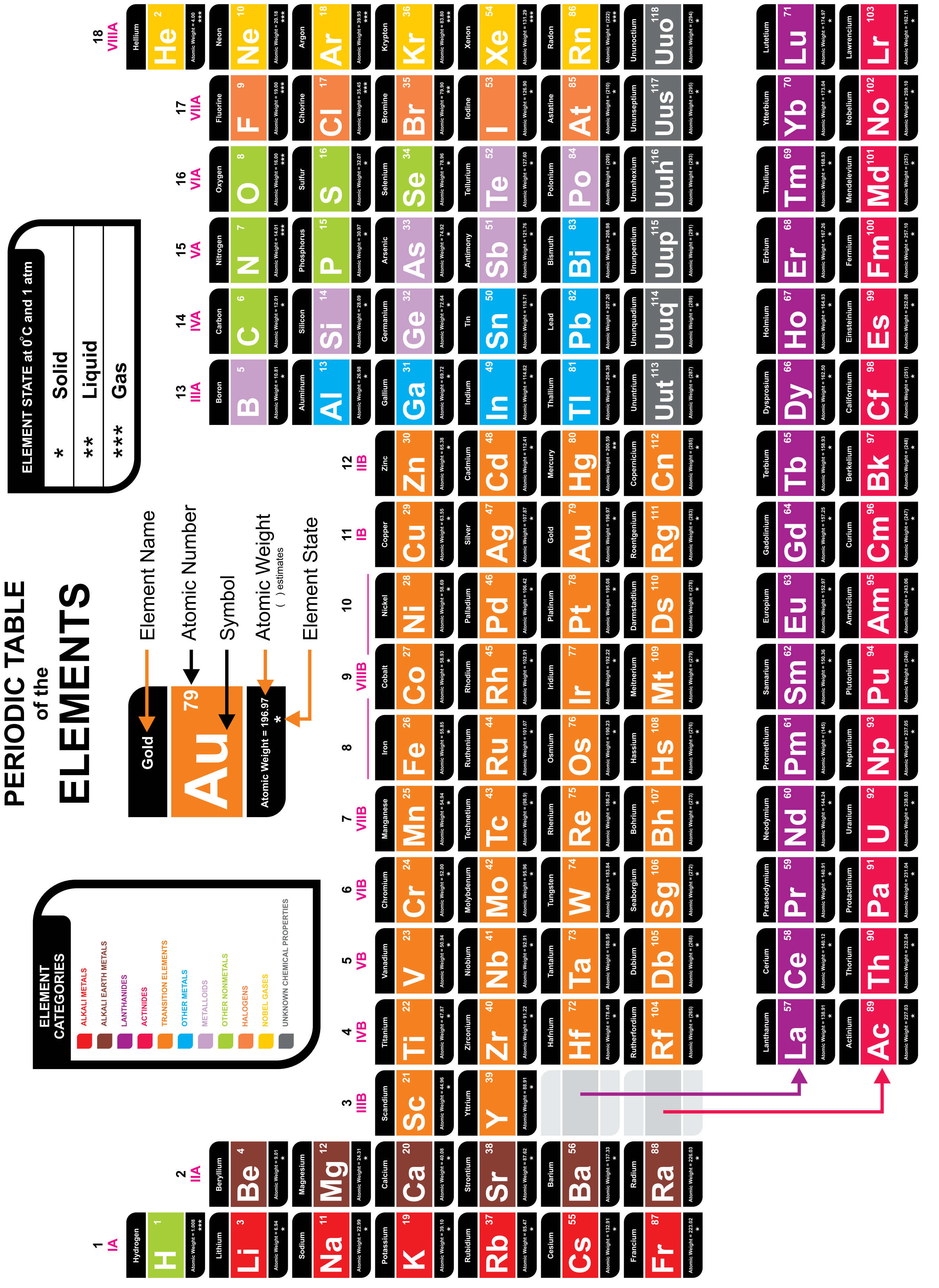

Figure 1-3. The periodic table of elements.

LIQUIDS

Liquid matter is characterized by molecules that have more energy and increased movement. This causes the molecules to be able flow and not take a rigid shape such as a solid. Liquids take the shape of their container even though the volume of a liquid does not change significantly. Liquids are said to be incompressible. While liquid molecules are able to slide past each other, they are still closely packed enough that the application of pressure does little to change the volume.

GASES

Matter also exists as a gas. This type of matter contains even more heat energy and movement in its molecules. A greater space between molecules exists. Gases take the shape of their container but unlike liquids, gases are compressible. When pressure is applied, the molecules can be made to exist closer to each other. It is possible to put a gas under so much pressure that it changes to a liquid state.

PLASMA

Plasma is a unique state of matter comprised of ionized gas consisting of positive ions and free electrons in proportions resulting in a relatively neutral electric charge. Plasma is also electrically conductive. It is sustained easily at the extremely high temperatures present in stars and as such is the most common form of matter in the universe.

CHANGES BETWEEN STATES

Matter can change between the states by adding or removing energy. The chemical composition of the material remains the same during all states of matter but the energy level causes it to be a solid, liquid, or gas. For example, water is always H_2O, pairs of hydrogen atoms bonded to a single oxygen atom loosely held next to each other in a liquid state. When energy is removed and water becomes ice, it is still H_2O. However, the motion of the molecules is greatly reduced and they no longer have the energy to slide past one another as a liquid. The same is true when heat energy is added to water. Water vapor is formed as the motion of the molecules causes more freedom of movement between molecules. But the water existing as a gas (vapor) is still formed from millions of H_2O molecules.

The heat energy added or subtracted to a substance is typically measured by temperature. The higher the temperature of a substance, the more energy it contains. Heat always flows from hot to cold. These terms (hot and cold) express the relative amount of energy present in the substance. Without a difference in energy levels, there is no transfer of energy (heat).

Adding heat to a substance does not always raise its temperature. When a substance changes state, such as when a liquid changes into a vapor, heat energy is absorbed. This is called latent heat. When a vapor condenses into a liquid, this heat energy is given off. The temperature of a substance remains constant during its change of state. All energy absorbed or given off, the latent heat, is used for the change process. Once the change of state is complete, heat added to a substance raises the temperature of the substance. After a substance changes into a vapor, the rise in temperature is caused by the addition of still more heat is called superheat.

The temperature at which a substance changes from a liquid into a vapor when heat is added is known as its boiling point. This is the same temperature at which a vapor condenses into a liquid when heat is removed. The boiling point of any substance varies directly with pressure. When pressure on a liquid is increased, its boiling point increases, and when pressure on a liquid is decreased,

Shell or Orbit Number	1	2	3	4	5
Maximum Number Of Electrons	2	8	18	32	50

Figure 1-4. Maximum number of electrons in each orbital shell of an atom.

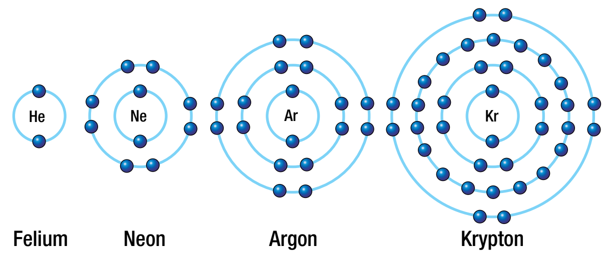

Figure 1-5. Elements with full valence shells are good insulators. Most insulators used in aviation are compounds of two or more elements that share electrons to fill their valence shells.

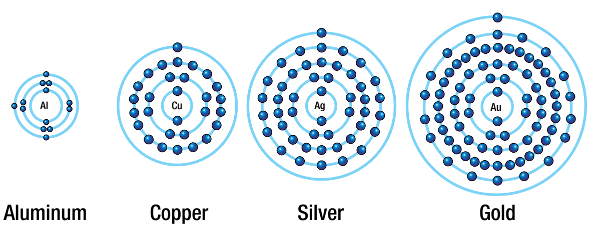

Figure 1-6. The valence shells of elements that are common conductors have one (or three) electrons.

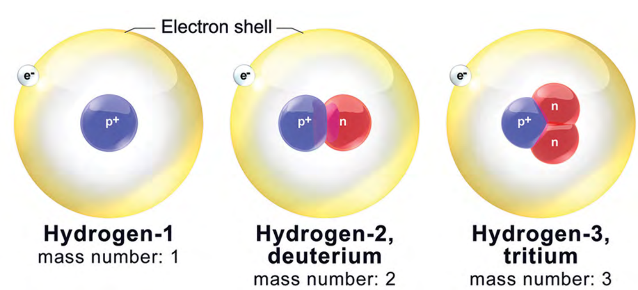

Figure 1-7. Isotopes of hydrogen.

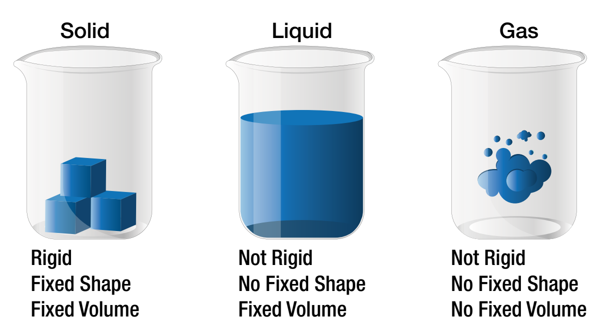

Figure 1-8. Solids, liquids, and gases in various states of density and movement.

its boiling point also decreases. For example, water boils at 100°C (212°F) at normal atmospheric pressure (14.7 psi). When pressure on liquid water is increased to 20 psi, it does not boil at 100°C. More energy is required to overcome the increase in pressure. It boils at approximately 108°C (226°F). The converse is also true. Water can also boil at a much lower temperature simply by reducing the pressure upon it. With only 10 psi of pressure upon liquid water, it boils at 90°C (194°F). [**Figure 1-9**]

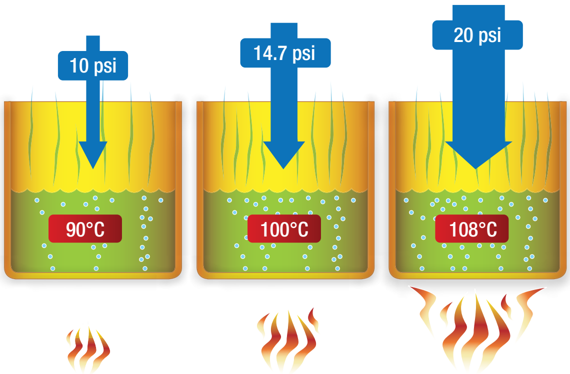

Figure 1-9. Boiling point of water changes as pressure changes.