Test review modules 2,3,4,5:::

Module 2 notes:

Key terms

- Law of Conservation of Mass
- Integer
- Uncertainty
- Significant figures
- SI unit
- Density
- Dimensional analysis

Trinity College Dublin, Founded in 1592
First chemistry faculty position independent of the medical school founded in 1711
Life without chemistry:
No soap/washing liquid/detergent/shampoo/paint/oil/drinking water/computers/air travel/cd's/fridges/fertilizers…… no modern life.
It cures diseases, controls infections, manipulate old drugs and improves the quality of life

Scientific method:

1) performing experiements
2) making observations
3) proposing a hypothesis(based upon the observations made)
4) confirming the hypothesis (by repeatd experimentation)
5) proposing a scientific law

Numerical Values

Expression of Numerical Value

Certain rules apply to the expression of the numerical value and the system of units used in scientific measurements (each to be discussed further on the following slides).

These include:

- **Scientific notation**
- **Significant figures** (digits)

SI system of units (based on the metric system)

Scientific Notation:

Ia a very convenient way of expressing very large or small #'s and at the same time provides a method of increasing efficientcy in scientific calculations.
It's a mathematical expression in which a number is expressed as:

N x 10..n where N contains only one nonzero digit and it's a n interger
Examples: express 2566 in scientific notation
256.6 x 10'
25.66 x 10' 2
2.566 x 10' 3

Significant Figures:

Rules for determining significant figures

1) all nonzero digits are significant figures
2) counting begins from the left with the first nonzero #'s ex. 0.987--3
3) zero's between nonzero digits are counted as significant figures
4) terminal zeros (zeros to the right of the number)

Chemical calculations:

Rule 1: (+,-)
Least decimal point=1 decimal point
Both have 2 dec. place = 2 dec. point.
Rule 2: (x, /)
Answer is ---The least significant figure

Rule 3:
The # of significant figure dictated by the measured quantity involved.--- exact #'s, unit conversion factors and constant have no effect on the # of significant figures.
Ex: if mass of steel is 2.35g what will be the total mass of 8---- 2.35g x 8= 18.8g

Rounding off digits:

SI system of units:
Kg/m^3----- density=mass/volume

Slide 11

Practice questions:

1. Patrick saw 3 cars in his driveway. The number has:

a) 1 significant figure
b) 0 significant figure
c) Infinite number of significant figures
d) 3 significant figures

2. An object had a mass of 15.9876 g when weighed on an analytical balance. The uncertain digit in the measurement is:

a) 1
b) 9
c) 5
d) 6

3. A quantity of 7.4 mg of a substance can be expressed in scientific notation as:

a) 7.4×10^{o} g
b) 7.4×10^{0} mg
c) (74/10) mg
d) 0.74 x 10 mg

4. A volume of 3.45 µL can be expressed in scientific notation as:

a) 3.45 mL
b) 3.45×10^{6} mL
c) 3.45×10^{-6} L
d) 3.45 µL

5. If the density of a substance is 1.70 g/mL, what is the mass of 9.20×10^{-3} L of this substance?

a) 9.202 g
b) 5.41 g
c) 1.56 × 10 g
d) 1.85×10^{-1} g

6. If 5.00 mL of a liquid has a mass of 4.9 g, its density (mass/volume; expressed in scientific notat significant figures and correct unit) is:

a) 0.98 g/mL
b) 9.8×10^{-1} g/mL
c) 98×10^{-2} g mL^{-1}
d) 9.80×10^{-1} g/mL

7. What is the diameter in centimeters of an all dressed jumbo (18 inch) pizza? [1 in = 2.54 cm]

a) 46 cm
b) 7.1 cm
c) 18 cm
d)

8. How many Canadian dollars must be paid to settle a bill for US$ 105.02? [US $ 1.00 = Can $ 1.29]

a) Can $ 135.48
b) Can $ 105.02
c) Can $ 81.41
d) Can $ 0.01

9. Using the formula, x = 2 πr, calculated value (with correct number of significant figures and expressed in scientific notation) of x when r = 1.25 cm and π = 3.142857 is:

a) 7.857142 cm
b) 7.86 x 10^{o} cm
c) 8 x 10^{o} cm
d) 7.86 x 10^{o}

10. Object A covered a certain distance in 1.8 x 10^{-9} s whereas to cover the same distance, object B took 3.6 ns. Which of the following statements is correct?

a) A and B are moving with the same speed
b) A is moving at half the speed of B
c) B is moving faster than A
d) A is moving at twice the speed of B

Matter

Key terms;

▪ Matter	▪ Electrons	▪ Mass number
▪ Mixture	▪ Protons	▪ Molecules
▪ Elements	▪ Neutrons	▪ Ions
▪ Compound	▪ Nucleus	▪ Cation
▪ Atoms	▪ Atomic number	▪ Anion

What is Matter?

he term "matter" is used to escribe things which:	**Matter can be classified in terms of its:**
occupy space (hence possess volume and mass) are perceivable by our senses	▪ physical state: solid (e.g., wood), liquid ▪ (e.g., water), or gas (e.g., air) ▪ chemical composition: element (e.g., copper), ▪ compound (e.g., sugar), ▪ or mixture (e.g., antifreeze)

Physical States of Matter

Solid/ liquid/ gas

Elements {copper} are composed of one type of atom. Elements are classified as metal, nonmetal, or metalloid (semi-metal).

Compounds [sugar] the elements are chemically combined to form the compound. A chemical change can break down a compound into its individual elements.

Mixture [antifreeze] non pure substance made up of more then 2 elements/compounds that can be separated by physical, not chemical procedures.

What are Atoms?

Atoms are composed of electrons, protons, and neutrons. The nucleus of the atom contains the neutrons and protons. The electrons surround the nucleus and are equal to the number of protons in a neutral atom.

Protons have a positive charge (p^+)

Neutrons have no charge (n^o)

Electrons have a negative charge (e^-)

Atomic & Mass Numbers

Atomic Symbol

The **atomic number** of an element (Z) is equal to the number of protons in the nucleus of its atoms. Each element has a different atomic number.

The **mass number** (A) is equal to the number of protons and neutrons in the atom. To calculate the number of neutrons, subtract the atomic number from the mass number:

Number of neutrons = A - Z

Every element has an **atomic symbol** (X). Both the atomic and mass numbers are included with the atomic

Molecules and Ions

Molecules	▪ Molecules are a combination of atoms in a definite proportion ▪ e.g., molecule of water (H_2O; hydrogen:oxygen = 2:1).
Ions	▪ Ions are charged species formed by loss or gain of electron(s) from ▪ an atom.
Cation	▪ Cation generation: M (g) $M^+(g)$ + e- (loss of e^-) [M = metal; ▪ g = gaseous state] [where M^+, a positively charged ion is the cation]
Anion	▪ Anion generation: X (g) + e^- X^- (g) (gain of e^-) [X = nonmetal] ▪ [where X^-, a negatively charged ion is the anion] ▪ Example: NaC(table salt) a compound, consists of Na^+(cation) & ▪ C^- (anion) ions.

Question

2. In terms of its physical state, the matter can be classified as:

a) Solid
b) Liquid
c) Gas
d) All of the answers apply

3. A neutral atom contains 6 electrons and has a mass number of 12. The number o neutrons in the atom is:

a) 18
b) 6
c) 12

Molecules are a combination of atoms in a definite proportion
Elements are composed of one type of atom
Anions are positively charged
Each element has a different atomic number
d) 2

5. Anions are formed by the:
a) Gain of electrons
b) Loss of electrons
c) Loss of neutrons
d) Gain of neutrons

6. Which of the following statements is true?
a) An ion containing 17 protons and 18 electrons is an anion
b) An ion containing 16 protons and 18 electrons is a cation
c) An ion containing 11 protons and 10 electrons is an anion
d) None of the answers apply

7. Which of the following statements is false?
a) Atomic number of an element is equal to the number of neutrons in the nucleus of its atoms
b) Atomic number of an element is equal to the number of protons in the nucleus of its atoms
c) Each element has a different atomic number
d) None of the answers apply

8. Which of the following statements is false?
a) Each element is composed of atoms
b) Every element has an atomic symbol
c) Each element has a different atomic number
d) The nucleus of the atom contains the electrons

9. An anion is formed when an atom gains electron(s).
a) True
b) False

10. Ions are charged species formed by loss or gain of electron(s) from an atom.
a) True
b) False

Module test

1. A volume of 12.6 mL is also equal to:
a) 1.26×10^{-3} L
b) 1.26×10^{3} L
c) 1.26×10^{-2} L
d) None of the answers apply

2. How many microlitres are there in 282.L?
a) 0.282 µL
b) 28.2 µL
c) 2.82×10^{3} µL
d) 2.82×10^{8} µL

3. The SI unit for length is feet.
a) True
b) False

4. All the elements in the periodic table contain the same number of protons.
a) True
b) False

5. Pure sugar is classified as:
a) Element
b) Compound
c) Mixture
d) None of the answers apply

6. Which of the following statements is false?
a) Electrons have a positive charge
b) Protons have a positive charge
c) Neutrons have no charge
d) Electrons have a negative charge

7. An ion containing 11 protons and 10 electrons has:
a) A negative charge
b) A positive charge
c) No charge
d) None of the answers apply

8. An ion containing 35 protons and 36 electrons has:
a) A negative charge

b) A positive charge
c) No charge

9. If the density of a liquid is 1.92 g/mL, what is the volume of 12.46 g of this liqui
a) 6.49×10^6 µL
b) 6.49
c) 6.49×10^3 µL
d) 1.54×10^2 µL

10. If 9.20 mL of a liquid has a mass of 15.6 g, what is its density?
a) 5.90 g/mL
b) 1.70×10^0 g/mL
c) 1.70 mL/g

11. The atomic number of an element is equal to the:
a) Number of neutrons in the atom
b) Number of protons in the atom
c) Sum of the number of protons and neutrons in the atom
d) Sum of the number of electrons and protons in the atom

12. The number of protons for a given element is given by:
a) Z
b) A
c) A--Z
d) Z—A

3. The correct answer (expressed in scientific notation) for the calculation,
6.56 g + 1.23 g + 1.29 g)/2.0 g is:
) 4.54
) 4.54×10^0
) 45/10
) 4.5×10^0

14. The correct answer (expressed in scientific notation) for the calculation,
6.6 g + 1.23 g + 1.29 g is:
a) 9.1 g
b) 9.12×10^0 g
c) 91.2/10 g
d) 9.1×10^0 g

15. Which of the following statements is true?
a) In a cation the number of protons is equal to the number of electrons

b) In an anion the number of electrons is equal to the number of protons

c) In a neutral atom the number of protons is equal to the number of electrons

d) None of the answers apply

16. A neutral atom contains 82 protons and 125 neutrons. The mass number of the neutral atom is:

a) 207

b) 43

c) 82

d) 125

17. The speed of light is 3.00×10^8 m/s. How far will a beam of light travel in 3.00 ns?

a) 9.00×10^{-1} m

b) 1.00×10^{-1} m

c) 9.00×10^8 m

d) None of the answers apply

18. The volume of a sphere [given by the relationship: $4.19 \times (\text{radius})^3$] of diameter 2.51 cm is:

a) 10.52 cm^2

b) 66.2 cm^3

c) 5.26 cm^3

d) 8.28×10^0 cm^3

19. How many micrograms are there in 3.0 ng?

a) 3.0×10^6 µg

b) 3.0×10^3 µg

c) 3.0×10^{-3} µg

d) 3.00×10^{-3} µg

20. How many inches are there in 4.5 cm? [1 in = 2.54 cm]

a) 1.8×10^0 in

b) 1.77×10^0 in

c) 5.6×10^{-1} in

d) 5.64×10^{-1} in

Module 3 notes:

Key terms

▪ Alkali metals	▪ Halogens
▪ Alkaline earth metals	▪ Noble gases

Elements and Groups

The periodic table is a chart (containing symbols) of all the known elements arranged by increasing atomic number (Z) of the element. (The atomic number is numerically equal to the number of protons in the nucleus of its atoms.)

Elements	▪ Elements are arranged into: vertical columns called **groups** (or families) and horizontal rows called **periods.** ▪ Elements in the same group (or family) have similar chemical propert ▪ . Elements in a period have different chemical properties. ▪ For each element, the atomic number is given at the top of the symbo ▪ and the atomic mass at the bottom. ▪ The periods are designated with the numbers 1 to 7.
Groups	▪ The groups are designated with the numbers 1 (I) to 8 (VIII) and a ▪ letter A or B. ▪ The elements in the groups with the letter A designation are referred ▪ as the main-group elements. ▪ The elements in the groups with the letter B designation are referred ▪ as the transition elements. ▪ The inner transition elements (lanthanides and actinides) are located ▪ between groups 3B and 4B. **Traditional Group Names:** ▪ Group 1A elements are called alkali metals. ▪ Group 2A elements are called alkaline earth metals. ▪ Group 7A elements are called halogens. ▪ Group 8A elements are called noble (or rare, or inert) gases.

Question

1. An element containing 12 protons and 12 electrons is a:

a) Metal
b) Non-metal
c) Metalloid
d) None of the answers apply

2. An element containing 33 protons is a:
a) Metal
b) Non-metal
c) Metalloid
d) None of the answers apply

3. The symbol for the halogen in the same period as potassium is:
a) Br
b) I
c) F
d) Cℓ

4. The symbol for the rare gas in the same period as sodium is:
a) He
b) Ne
c) Ar
d) None of the answers apply

5. A neutral atom contains 45 electrons and has a mass number of 103. The numbe of neutrons in the atom is:
a) 148
b) 103
c) 45
d) 58

6. A neutral atom contains 12 protons and has a mass number of 24. The number of neutrons in the atom is:
a) 12
b) 24
c) 36
d) None of the answers apply

7. An anion M^- contains 10 electrons. The number of electrons in the neutral atom (from which the anion is formed) is given by:
a) 1
b) 8
c) 9
d) None of the answers apply

8. An anion M^- contains 9 protons. The number of electrons in the neutral atom (from which the anion is formed) is given by:

a) 1
b) 8
c) 9
d) None of the answers apply

9. An anion is formed by gain of electron(s) by an atom.

a) True
b) False

10. A cation contains more electrons than protons.

a) True
b) False

Naming Compounds:

Key terms

▪ Ionic compounds	▪ Bases
▪ Polyatomic ions	▪ Mole
▪ Acids	▪ Atomic masses

Classifying Compounds

An Ionic Compound
- sodium chloride, NaCl

The crystal structure of sodium chloride, NaCl, a typical ionic compound. The purple spheres are sodium cations, Na^+, and the green spheres are chloride anions, Cl^-. (Source: Benjah-bmm27, Wikimedia)

Chemical compounds are classified as:

- **Organic:** Compounds that contain at least one carbon atom.
- **Inorganic:** Compounds that contain atoms other than carbon.
  Exceptions are inorganic compounds such as carbon monoxide (CO), carbon dioxide (CO_2), etc.

For the purpose of **nomenclature** (systematic naming), inorganic compounds are classified as those:

- containing a metal and a nonmetal (ionic compounds)
- containing two nonmetals (covalent compounds)

More about Ionic Compounds

Ionic compounds are composed of ions. They are formed by the electrostatic attraction between a positive ion (cation from the metal) and a negative ion (anion from the nonmetal). Electrons are transferred from the atoms of one element to the atoms of another element.

In general, metals lose electrons and nonmetals gain electrons. Ionic compounds are charge neutral (zero net charge). Charges on ions involved in an ionic compound must be known in order to name the compound formed between them or to derive the formula for the compound.

Rules for compounds:

Rule #1:
For metals of group's 1A, 2A and 3A, the charge on the formed monatomic cation is equal to the group number. (Always named first)

Rule #2:
Nonmetals of group 5A, 6A and 7A, the charge on the formed monatomic anion is equal to the group minus 8.

Rule #4:
Ions that consist of two or mare atoms bonded covalently net positive or negative charges are referred to as polyatomic ions.

Rule #5:
When an acid dissociates (breaks up) it produces H ions and a counted ion of equal but opposite charge.

Iconic compounds: (ex:)

a) NaCℓ **=** Metal Na (sodium); Nonmetal Cℓ (chlorine)

For sodium: Na is a Group 1A element hence has a charge +1

(**Rule #1**): Cation: Na^+

Na^+ is sodium since it is a cation (**Rule #1**).

For chlorine: Cℓ is a Group 7A element hence has a charge of -1

(**Rule #2**) Anion: $C\ell^-$

$C\ell^-$ is chloride since it is an anion (**Rule #2**).

The name of the compound is Sodium chloride.

b) Calcium nitride = Calcium is Ca^{2+}; nitride is N^{3-}.

Therefore, to have a zero net charge, three Ca^{2+} ions balance two N^{3-} ions.

The formula is **Ca_3N_2.**

c) Iron(III) nitrate = Iron is Fe^{3+}(**Rule #3**); nitrate is NO_3^-.

Therefore, to have a zero net charge, one Fe^{3+} ion balances three NO_3^- ions.

The formula is **$Fe(NO_3)_3$.**

d) Cu_2O = Anion:O^{2-} and Cation: Cu^+.

Copper is the cation Cu^+ and the ionic charge is indicated by the Roman numeral (I) because it can form more than one cation.

O^{2-} is oxide since it is an anion. To neutralize the charges, two Cu^+ ions balance one O^{2-} ion.

The name of the compound is **Copper(I) oxide**.

Covalent Compounds

Rules for Naming Covalent Compounds

- **Rule #1:** Name the first element in the formula first.
- **Rule #2:** Name the second element as an anion.
- **Rule #3:** Use prefixes to indicate the numbers of atoms of each element.
- **Rule #4**: Do not use the prefix mono- for the first element.

e) What is the name of $CC\ell_4$ =

C is the symbol for carbon (nonmetal) (**Rule #1**).

The second element is named chloride (**Rule #2**). There are four chlorine atoms and this is indicated by the prefix tetra-. The name is **carbon tetrachloride**

f) What is the formula of dioxygen difluoride =

Oxygen is the first element. O is the symbol for oxygen (nonmetal) (**Rule #1**). Two oxygen atoms are indicated by the prefix di- (**Rule #3**).

F is the symbol for fluorine. Fluorine is the element corresponding to the anion, thus it is named fluoride (**Rule #2**). The prefix di- indicates two fluorine atoms in the formula (**Rule #3**). The formula is O_2F_2

Chemical Reactions:

Chemical reactions are expressed as an equation.
Coefficients are the numbers written in front
Subscripts are the bottom

Be able to balance equation (old book ad.eid)

A mole can be "packaging unit" for atoms, molecules, and ions. Always refer to it by the number 12.
Mole = 6.022 x 10^23 (Avogadro's number).

Atomic masses (mass of 1 mole of atoms or mass of 6.022 x 10^23 atoms) of elements are given in the periodic table.

Molecular mass (or formula mass)= sum of atomic masses

Ex: [Ca(NO'3)'2] calcium nitrate;;;;;;;;;;;;;;;;
Ca: 1 x 40.08 g/mol = 40.08 g/mol
N: 2 x 14.01 g/mol = 28.02 g/mol
O: 6 x 16.00 g/mol = 96.00 g/mol
Total: = 164.10 g/mol

Mole = mass in grams/ molar mass (formula mass)

Ex: how many moles are there in 98.0g sulfuric acid?

Molar mass (H'2SO'4)= 2 x 1.008 + 1 x 32.06

Question

1. In order to avoid the fractional coefficient the balanced equation:
C_4H_{10} (g) + 6.5 O_2 (g) → 4 CO_2 (g) + 5 H_2O (ℓ) must be:
a) Multiplied by 2 (all the coefficients)
b) Multiplied by 4 (all the coefficients)
c) Multiplied by 2 (coefficients for the products only)
d) Multiplied by 2 (coefficients for the reactants only)

2. What are the coefficients for the reactants and the products when the equation f the reaction:
SiO_2 (s) + HF (aq) → SiF_4 (g) + H_2O (ℓ) is balanced?
a) 1, 4, 1, 2
b) 2, 8, 2, 1
c) 2, 3, 1, 6

3. The reaction between solid potassium carbonate and aqueous sulfuric acid producing aqueous potassium sulfate, gaseous carbon dioxide and liquid water is correctly written as:

a) K_2CO_3 (aq) + H_2SO_4 (s) → K_2SO_4 (aq) + CO_2 (g) + H_2O (ℓ)
b) K_2CO_3 (aq) + H_2SO_4 (aq) → K_2SO_4 (aq) + CO_2 (g) + H_2O (ℓ)
c) K_2CO_3 (s) + H_2SO_4 (aq) → K_2SO_4 (aq) + CO_2 (g) + H_2O (ℓ)
d) 2 $KHCO_3$ (s) + H_2SO_4 (aq) → K_2SO_4 (s) + 2 CO_2 (g) + 2 H_2O (ℓ)

4. The reaction between aqueous sodium sulfate and aqueous barium nitrate producing aqueous sodium nitrate and solid barium sulfate is correctly written as:

a) Na_2SO_4 (aq) + $Ba(NO_3)_2$ (aq) → $NaNO_3$ (aq) + $BaSO_4$ (s)
b) Na_2SO_4 (aq) + $Ba(NO_3)_2$ (aq) → $NaNO_3$ (aq) + $BaSO_4$ (aq)
c) Na_2SO_4 (aq) + $Ba(NO_3)_2$ (aq) → 2 $NaNO_3$ (aq) + $BaSO_4$ (s)
d) None of the answers apply

5. The correct name for SF_6 is:

a) Fluoride of silicon
b) Monosulfur hexafluoride
c) Sulfur hexafluoride
d) Hexaafluorosulfur

6. The correct name for Fe_2O_3 is:

a) Iron oxide
b) Iron trioxide
c) Iron(III) oxide
d) None of the answers apply

7. The formula for hydrogen carbonate ion is:

a) H_2CO_3
b) CO_3^{2-}
c) HCO_3^{2-}
d) HCO_3^-

8. The formula for sulfuric acid is:

a) H_2SO_4
b) $H(SO_4)_2$
c) $H_2(SO_4)_2$
d) None of the answers apply

9. How many moles are there in 64.06 g of sulfur dioxide?
a) 2.00 moles
b) 4.00 moles
c) 3.00 moles
d) 1.000 moles

10. How many micrograms are there in 2.00 moles of calcium atoms?
a) 4.01×10^7 µg
b) 8.02×10^7 µg
c) 1.60×10^7 µg
d) 2.00×10^7 µg

Module Test

1. The elements Na, Mg, Aℓ, Si, P, S, Cl, Ar are in the same:
a) Period
b) Group
c) Section
d) None of the answers apply

2. In the Periodic Table, the halogens are in the same:
a) Period
b) Group
c) Section
d) None of the answers apply

3. Hydrogen sulfide is a compound containing nitrogen and oxygen.
a) True
b) False

4. Methane is a compound containing carbon and hydrogen.
a) True
b) False

7. The symbol for an ion containing 18 electrons and 15 protons is:
a) P
b) S^{2-}
c) P^{3-}
d) None of the answers apply

8. The symbol for an ion containing 7 protons and 10 electrons is:
a) N
b) N^{3-}
c) O^{2-}
d) None of the answers apply

9. How many grams of a compound will contain 1.204×10^{24} molecules of the compound [Molar mass of the compound = 18.00 g/mol]
a) 3.600 × 10 g
b) 1.800 × 10 g
c) 6.022×10^{23} g
d) 1.204×10^{24} molecules

10. One mole of magnesium atoms contains:
a) 1 atom of magnesium
b) 6.022×10^{23} atoms of magnesium
c) 6.022×10^{-23} atoms of magnesium
d) 1 g of magnesium

11. The sodium ion contains:
a) 11 protons and 10 electrons
b) 11 protons and 11 electrons
c) 10 protons and 11 electrons
d) 10 protons and 12 electrons

12. The sulfide ion contains:
a) 16 protons and 16 electrons
b) 16 protons and 14 electrons
c) 14 protons and 16 electrons
d) 16 protons and 18 electrons

13. Aluminum nitrate has the formula:
a) $AlNO_3$
b) $Al(NO_3)_3$
c) Al_2NO_3
d) $Al_2(NO_3)_3$

14. Calcium sulfide has the formula:
a) CaS_2
b) Ca_2S
c) CaS

15. If under a set of optimum conditions, 2.00 moles of nitric acid are produced fro the reaction between 1.00 mole of dinitrogen pentoxide and water, how many mol of dinitrogen pentoxide will be required (under similar conditions) to produce 30.0 moles of nitric acid?

a) 15.0 moles
b) 30.0 moles
c) 20.0 moles
d) 10.0 moles

17. In the balanced equation for the reaction between aluminum metal and gaseou oxygen forming aluminum oxide, the coefficient for aluminum oxide is:

a) 1
b) 3
c) 4
d) 2

18. What is the coefficient for oxygen when the equation for the reaction: **C_4H_8 (g) + O_2 (g) —> CO_2 (g) + H_2O (l)** is balanced?

a) 3
b) 6
c) 1
d) 12

19. Covalent compounds are formed by the electrostatic attraction between a meta cation and nonmetal anion.

a) True
b) False

20. In general, metals gain electrons and nonmetals lose electrons.

a) True
b) False

Module 4: Hazards in the Work Environment

The Environment and Our Health

Our physical and mental well-being (the state of our health), is determined by a combination of hereditary factors and the quality of the environment we encounter. However, it is very important to realize that the term environment includes home, community, workplace and

recreational environments. All of these individually or collectively can have a significant impact on our health.

Types of Hazards

In a workplace, the worker may be exposed to:

Safety hazards	Health hazards
Based on the nature of the work, safety hazards are due to material handling, machines, energy, work practices, and confined spaces. ▪ **Material handling hazards**: These can lead to muscle strains due to lifting and carrying materials. The use of devices such as forklifts, cranes, etc. exposes the worker to accidental contact with the moving equipment. ▪ **Machine hazards:** Rotating shafts, moving belts, presses, etc. can cause very serious injuries. ▪ **Energy hazards:** All energy sources such as electricity, steam, hydraulic pressure, etc. can lead to serious injury. ▪ **Work practice hazards:** Failure to follow safe operating procedures may lead to serious injuries. ▪ **Confined space hazards:** In such spaces (for example, silos, storage tanks, pipelines etc.) hazards arise due to difficulty of entry and exit, build-up of hazardous materials and oxygen deficiency.	The extent of occupational health hazards varie with the type of activity. However, such hazard may have the potential to cause severe discomfort, illness, and lack of efficiency among workers. Based on the nature of the causative agent (or factor), occupational health hazards can be classified as physical, chemical, biologic and ergonomic. ▪ **Physical hazards** are due to the presence of ▪ physical agents such as pressure and ▪ temperature extremes, excessive noise and ▪ vibration, and exposure to radiation. ▪ **Chemical hazards** are due to the presence o ▪ chemical agents such as dust, fume, gas, mis ▪ smoke and vapor. ▪ **Biological hazards** are due to the presence ▪ biological agents such as bacteria, moulds ar ▪ viruses. ▪ **Ergonomic hazards** are due to ergonomic ▪ stresses such as fatigue and repetitious work

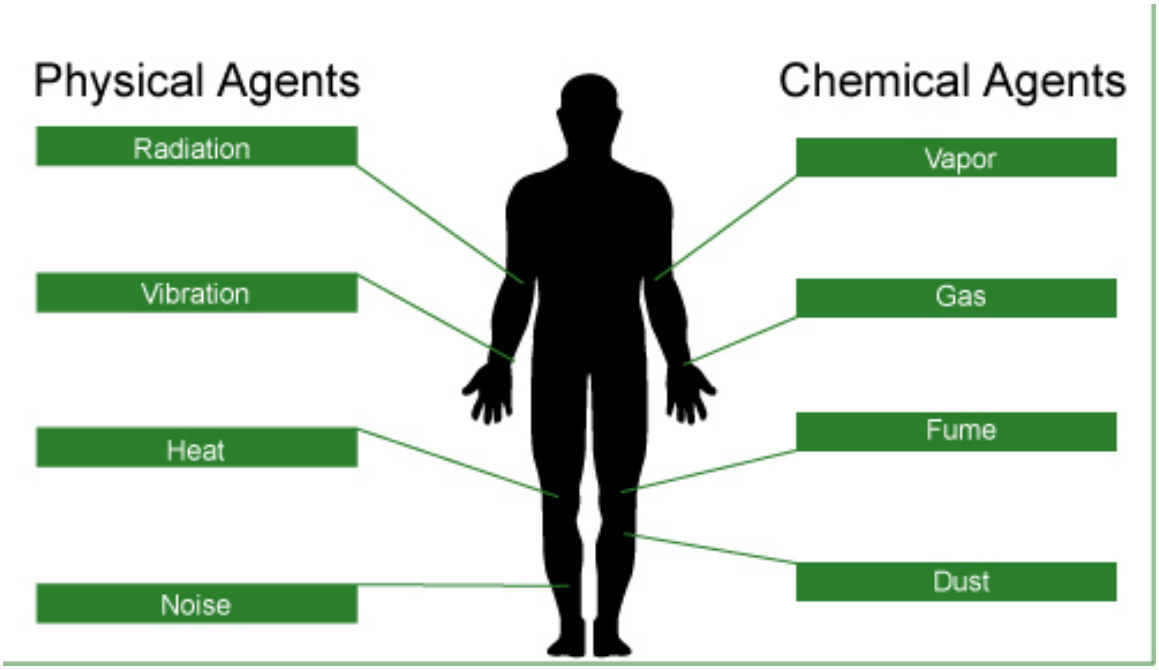
Physical and Chemical

It is very important to note that the mere presence of a causative agent does not necessarily constitute a hazard. A causative agent is classified as hazardous in certain circumstances such as high concentration or intensity and a prolonged exposure.

Workers have the right to:

- Work in a safe and healthy environment
- Know the processes and substances they are working with

Know potential hazards from these processes and substances



Hazard Assessment

In order to recognize and assess the potential impact of occupational hazards, walk-through surveys are performed. Such surveys generally include a study of the following parameters in terms of their impact on the surrounding environment and thus the workers.

Processes, operations and related activities

- Generally various emissions are evaluated because the emission of any physical, chemical or biological agents has the potential to be a health hazard.

Equipment

- Equipment is generally assessed in terms of mechanical and electrical safety and the potential to create excessive noise and vibration.

Properties of substances used and produced

- These include an evaluation of raw materials and finished products in terms of their physical, chemical and toxic properties and effects.

Control measures

All engineering controls in place for proper materials handling, storage, etc. are evaluated. Also considered are the ventilation system and the availability of personal protective equipment.

Physical Agents

Although we are constantly exposed to such agents, their intensity and duration of exposure may be more significant in the workplace. Such agents may cause immediate or cumulative adverse health effects.

Commonly encountered physical conditions with a potential to cause adverse health effects include:

- pressure and temperature extremes
- excessive noise and vibration
- radiation

The action of physical agents consists of transfer of residual energy through the surrounding air or the equipment the worker is in contact with. Except for radiation our senses can detect all other physical agents.

Pressure Extremes: Hypobaric

Ex: Airline pilots in the cockpit of an aircraft.

Hyperbaric is defined as a pressure higher than normal atmospheric pressure. Mining and underwater workers may be exposed to hyperbaric conditions.

Hypobaric is defined as a pressure lower than atmospheric pressure. Those working at high elevations such as ski instructors and airline pilots encounter hypobaric conditions.

▪ Temperature Extremes

The biochemical processes in one's body take place within a very narrow temperature range and hence the regulation of body temperature is an important function. Temperature extremes affect the working efficiency as well as the health of a worker.

Hot or cold depends on various factors

It is important to realize that apart from the surrounding temperature, sensation of hot or cold depends on some other factors such as:

Air movement	Hot or cold objects in the vicinity	Relative humidity

The terms heat stress and cold stress refer to excessive exposure to very hot or very cold work environments. Both such conditions may interfere with worker's

Heat	Cold
Some of the adverse effects in very hot work environments (depending upon the individual worker and the heat intensity) include: ▪ Heat exhaustion ▪ Fainting ▪ Heat stroke Heat-related problems may arise for: ▪ Outdoor workers (working in construction) ▪ Industrial workers (working near furnaces).	In very cold work environments (dependi and intensity of cold), the adverse effects include: ▪ Frostbite ▪ Hypothermia Workers at risk include: ▪ Outdoor workers (divers) ▪ Meat packers and handlers (working in ▪ refrigerated warehouses)

Excessive Noise

Noise is a form of irregular vibration. It may be conducted through gases (or vapors), liquids, or solids. Above a certain level, the noise becomes of concern because it may hinder communication between workers, thus leading to annoyance. This in turn may lead to poor job performance and compromise the safety of the worker. In addition, excessive exposure to high noise levels may cause loss of hearing.

Excessive Vibration

It is important to note that exposure to vibration is more than just a nuisance. Whereas exposure to vibration may cause discomfort, intense vibration has been known to cause serious health problems such as back pain, carpal tunnel syndrome (a condition affecting the hand and wrist) and damage to bones and joints.

There are two types of occupational vibration: whole-body and hand-arm vibration. Whereas whole-body vibration is transmitted through the supporting surface (feet, back, etc.), hand-arm vibration is transmitted to the hands and arms. Examples include: Mining equipment (whole-body vibration) and Hand-held power tools (hand-arm vibration).

Radiation

Graphic depicting ionizing and non-ionizing radiation (Source: Health Canada)

The hazard associated with a particular type of radiation depends on its energy and ability to penetrate the body tissue. Thus, even brief exposure to high energy and highly penetrating x-rays can cause severe damage to the tissue. Infrared, ultraviolet and microwaves on the other hand do not penetrate appreciably below the skin and the damage is mainly restricted to burns to the skin and eyes. Severe damage to eyes may result from excessive exposure to ultraviolet radiation.

▪ Types of Radiation

Radiation is the energy that travels through space from many different natural and human-made sources. Some different types of radiation include: visible light, ultraviolet rays, microwaves, x-rays and radio waves. Thus, it is easy to see that w are exposed to radiation every day.

Depending on its energy, radiation is of two main kinds:

Ionizing radiation: The energy associated with it is high and thus strong enough to damage cells and DNA. Some examples and sources of ionizing radiation include:

- x-rays (from x-ray machines)
- alpha, beta and gamma rays (from radioactive materials
- high-energy ultraviolet (from germicidal lamps).

Non-ionizing radiation: It is not as strong as ionizing radiation. However, prolonged exposure to some types of non-ionizing radiation can still cause harm. Some exampl and sources of non-ionizing radiation include:

- visible light, microwaves (from telecommunications and
- microwave ovens)
- infrared (from infrared heat lamps)
- radio waves (from broadcasting)
- low-energy ultraviolet (tanning lamps)

Above **Ionizing radiation symbol** (red) The new supplementary ionizing radiation warning symbol launched on 15 February 2007 by the International Atomic Energy Agency (IAEA) and the International Organization for Standardization (ISO). Contains radiating waves, a skull and crossbones and a running person. Note: Will only replace the standard yellow radiation trefoil symbo in certain specific limited circumstances (Source: International Atomic Energy Agency, Wikimedia)

Radiation Applications

Some applications of radiation include:

- Industrial: Quality control, non-destructive testing using radiography
- Household: Television, smoke detectors
- Medical: Imaging, treatment
- Science: Material analysis, sterilization

Chemical Agents:

Hazards in the workplace:
Potential risk a large variety of chemical agents are encountered in workplaces due to the diversity of raw materials and processes used.

Chemical hazards in such environments arise due to the presence of certain chemical agents whose properties (physical and/or chemical) or toxicity may pose a potential risk to the health and safety of the worker coming in contact with it or handling it.

Where do chemical hazards come from??

Hazards may arise in operations:

- **Compressed Gases:** chlorine gas are compressed and thus stored in cylinders under high pressure.
- **Flammable and combustible Materials**: such materials may burn readily in the presence of sources of ignition. (Gasoline and solvent).

- **Oxidizing materials**: can contribute strongly to the fire hazard, they posses the ability to oxidize and thus destroy, the biomolecules in the living systems. Some commonly encountered oxidizers in the workplace such as; potassium permanganate, hydrogen peroxide.
- **Poisonous materials**: dangerous to life in very small amounts ex; potassium cyanide and mercury salts.
- **Dangerously reactive materials**: may undergo rapid or violent reactions under certain conditions. Ex: alkali metals react with water producing highly flammable hydrogen gas.
- **Corrosive materials**: cause deterioration of material including living tissues on contact ex: sulfuric acid and potassium hydroxide.

Agents may be presents in the air as:

- **Fine particles:** less than 5 microns (5 x 10^6m) are the most hazardous because of their effective entry and retention in the lungs. Classified as dust, fume and smoke (for solids) , and mist (for liquids). Sources of fine particles include: spray painting (mist) / welding (fume) / incomplete combustion of oil and grease (smoke) / ore grinding (dust).
- **Gases and vapors:** result of various operations and can mix and distribute rapidly throughout the workplace. Gases can enter the bloodstream through the lungs. Toxic gases and vapors: solvent degreasing (vapors of solvent used) / spray painting (vapor of solvent used) / welding (gaseous combustion products).
- **Both as particles and vapors at the same time**
- **Absorbed/gases or vapors on particles**

Biological Agents

Biological agents are living organisms, or substances produced by such organisms, that can cause illness or disease in humans. The adverse health effects due to biological agents may range from allergic reactions to serious medical conditions and even death. Food poisoning, rabies, tuberculosis and hepatitis are some of the infections caused by biological agents.

These include: bacteria, fungi, viruses and other micro-organisms

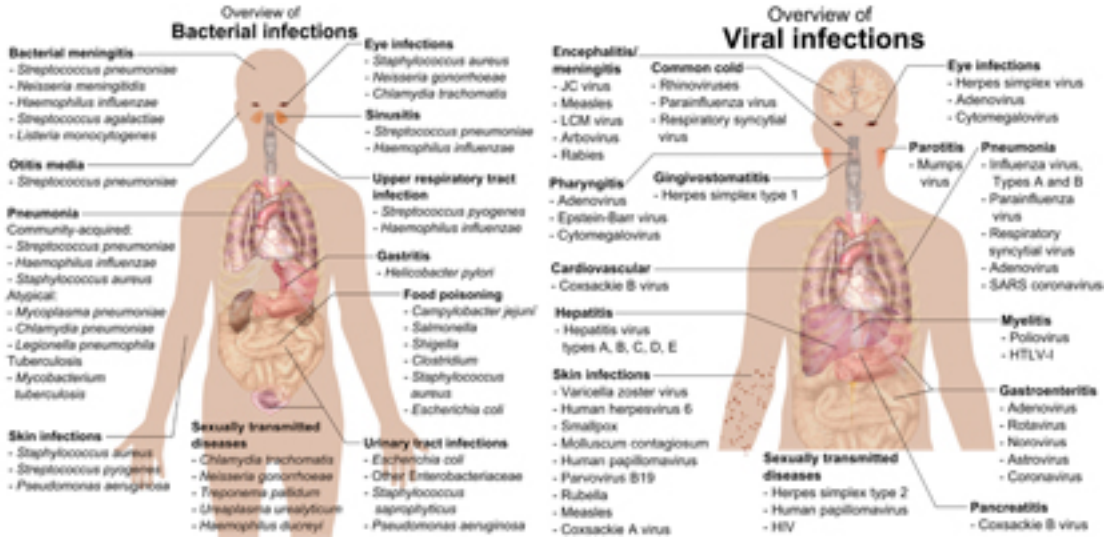
and their associated toxins

Workplace Exposure

Many micro-organisms pose a potential danger in a variety of workplaces due to their ability to:

- Reproduce rapidly
- Survive with minimum resources

Workplace exposure to work-related biological agents such as bacteria, moulds, and viruses is limited to certain occupations such as health care workers (i.e., hospital workers and veterinarians), meat handlers (i.e., ranchers, farmers, and meat packers), and those who work in sanitation or sewage operations.



Ergonomic Stresses

Ergonomics: the science of designing user interaction with equipment and workplaces to fit the user (Source: Ergonomics, Integrated Safety Management, Berkeley Lab, Wikimedia)

Ergonomics can be defined as the science or study of work. It is a way of designing a work environment to fit people.

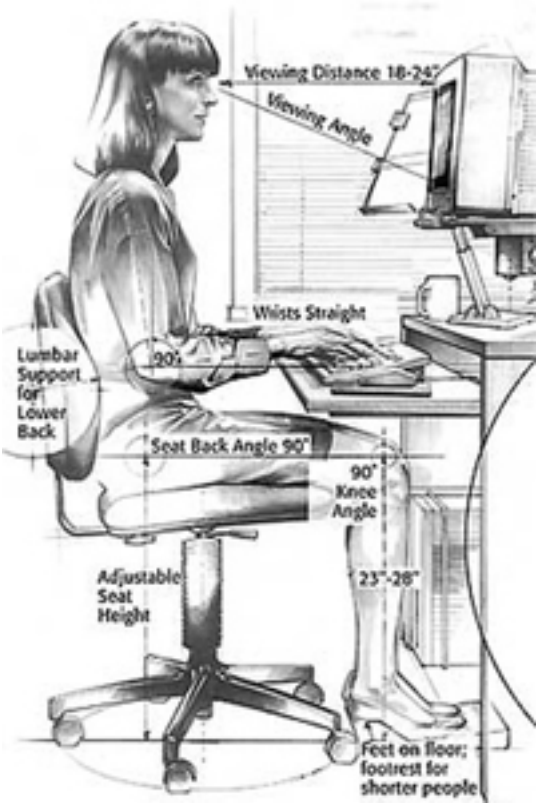
Over the recent years it has been fully realized that the traditional method of assigning people to jobs without accommodating their

needs, limitations, sizes, strengths and weaknesses may lead to certain adverse job safety and health issues such as mental stress, loss of efficiency and accidents.

It has been established that ergonomics, properly applied, can help:

- reduce workplace injuries and illnesses; particularly back injuries and cumulative trauma disorder (CTD) affecting, joints, muscles, nerves and tendons that can cause pain and swelling
- improve productivity and quality of work
- increase job satisfaction

satisfy government regulations



1. It is known that intense vibration may cause serious health problems such as:

a) Back pain
b) Carpal tunnel syndrome
c) Damage to bones and joints
d) All of the answers apply

2. A mountain climber at an altitude of 6,000 meters may be subjected to pressure conditions described as:

a) Atmospheric

b) Hyperbaric
c) Hypobaric
d) Hyperatmospheric

3. Which of the following statements is true?
a) Noise is a form of irregular vibration
b) Microwaves penetrate appreciably below the skin
c) X-rays are not damaging to body tissue
d) Radiation can be detected by human senses

4. Which of the following statements is false?
a) Noise is a form of irregular vibration
b) Microwaves penetrate appreciably below the skin
c) X-rays are damaging to body tissue
d) Radiation cannot be detected by human senses

5. Hazard posed by exposure to excessive vibration is classified as:
a) Chemical
b) Biological
c) Ergonomic
d) Physical

6. Hazard posed by exposure to excessive noise is classified as:
a) Chemical
b) Biological
c) Ergonomic
d) Physical

7. The hazard posed by sulfuric acid (a corrosive material) is classified as:
a) Physical
b) Chemical
c) Biological
d) Ergonomic

8. The hazard posed by metallic sodium (a dangerously reactive material) is classified as:
a) Chemical

b) Physical
c) Biological
d) Ergonomic

9. It is important to note that exposure to intense vibration has been known to cau serious health problems.
a) True
b) False

10. Ergonomic stresses arise as a result of less than optimal adjustment between the worker and the work or workplace.
a) False
b) True

Toxicology

Learning Objectives

After completing this section, you will be able to:

- **Define toxicology:** is the science that involves the study of the properties and the interactions of physical, chemical or biological agents.
-
- Discuss the basic concepts of **toxicology** as applied to chemical agents.: is the degree of danger of material to injure a living organism by other mechanical means.
-

Explain some of the **toxic hazards** posed by chemicals.:

Posed by a chemical are influenced by a number of factors such as: Physical/ chemical properties/ intensity of exposure (exposure dose: concentration x duration of exposure) / mode of handling / routes of entry / susceptibility of the worker

Respiratory tract (by inhalation)
Digestive tract (by ingestion)
Cutaneous- skin and eyes (by absorption)

Dose and Exposure

Dose

Dose is defined as the amount of toxicant(s) actually delivered to the target organ. The units used to express dose are mg/kg (mass of toxicant/body mass).

Exposure

Exposure on the other hand is the total amount of the toxicant(s) present in the workplace. However, exposure does provide an indication of the dose. Higher the exposure, greater the probability of larger amounts being delivered to the target organ and hence higher the dose.

The units used to express exposure are:

- mg/m^3 (mass of toxicant/volume of air) for particles
ppm (parts per million) for gases and vapors

Threshold Limit Values

In order to provide guidelines for controlling occupational health hazards, Threshold Limit Values (TLVs) for various physical and chemical agents have been developed by the American Conference of Governmental Industrial Hygienists (ACGIH).

Example: Which of the following statements is true based upon the information that the TLVs for two chemicals X and Y are 15 ppm and 5 ppm respectively?

(a) Y poses less risk than X

(b) Y poses more risk than X

(c) X and Y pose the similar risk

(d) X poses more risk than Y

According to ACGIH, one of the ways to specify these values is as Threshold Limit Value-Time-Weighted Average (TLV-TWA). It is the time-weighted average concentration of a substance for a normal 8-hour workday and a 40-hour workweek to which nearly all workers may be repeatedly exposed, day after day, without adverse effects.

Therefore, the lower the TLV value, the more potentially dangerous (or high risk) the substance is.

The Effects of Toxicants

Classification for the effects of over exposure to toxicants (or the commonly used term contaminants) can be based upon:

- Duration of the effect
- Organs affected and physiological action

Duration of the Effect

Acute effect: if it appears soon after exposure. The effect results from brief exposure to a high concentration of the contaminant. It's easy to observe and relate.

Chronic Effect: much later after exposure. Results from low and repeated exposure over a long period of time, may have latency periods. More difficult to study and are very important to consider when dealing with hazardous wastes and pollution.

Physiological Effects

Asphyxiants: hinder the body in the maintaining an adequate supply of oxygen. Leads to suffocation due to lack of oxygen Ex: carbon monoxide and cyanides.\

Irritants: cause eye, skin, and mucous membrane irritation Ex: ozone, hydrogen sulfide.

Anasthetics: act as depressants Ex: chloroform, alcohols.

Narcotics: are habits forming depressants. Ex: morphine, Demerol.

Systemics: cause organ or system damage. Ex: benzene, phenol.

Lung scarring agents: cause lung damage… lung cancer EX: mineral dust, asbestos.

Carcinogenic effect: cause cancer EX: ethylene dibromide, vinyl chloride. Ability to cause cancer in exposed workers, other human population or test animals.10-20 years or longer after exposure to carcinogen.

Mutagenic effect: changes DNA Ex: benzene, ethylene oxide.
Mutations in DNA of cells from ppl or test animals, which may result in disease or abnormalities in future generations. In WHMIS, classified as VERY TOXIC if in sperm and egg cells. Or in skin or lungs.

Teratogenic Effect: cause malformations in newborns EX; organic mercury compounds, Anaesthetic gases (nitrous oxide).

Teratogenic and embryotoxins can cause birth defects, abnormalities, developmental delays, r deaths in animal offspring's in the absence of significant harmful effect on the mother.

Question

1. The organization responsible for developing TLVs is abbreviated as:
a) AGCIH
b) ACGIH
c) AHGIC
d) ACGHI

2. The organization responsible for developing TLVs is abbreviated as:
a) AGCIH
b) ACGHI
c) AHGIC
d) None of the answers apply

3. Toxic hazards posed by a chemical are influenced by its:
a) Physical properties
b) Chemical properties
c) Exposure dose
d) All of the answers apply

4. The most common natural routes of entry of chemical agents into the body include:
a) Respiratory tract
b) Digestive tract
c) Skin
d) All of the answers apply

5. Which of the following statements is true based on the information that the TLVs for two chemicals X and Y are 2.5×10^2 ppm and 4.5×10^2 ppm respectively?
a) X poses more risk than Y
b) Y poses more risk than X
c) X and Y pose the similar risk
d) X poses less risk than Y

6. Which of the following statements is false based on the information that

the TLVs for two chemicals X and Y are 25.0 ppm and 4.5 × 10 ppm respectively?

a) X poses more risk than Y
b) Y poses less risk than X
c) X and Y pose the similar risk
d) None of the answers apply

7. Chemicals causing malformations in newborns are classified as:

a) Asphyxiants
b) Cancinogens
c) Teratogens
d) Narcotics

8. Habit forming depressants are classified as:

a) Asphyxiants
b) Teratogens
c) Narcotics
d) Irritants

9. The lower the TLV value, the more potentially dangerous (or high risk) the substance is.

a) True
b) False

10. Toxicity is the degree of danger of a material to injure a living organism by other than mechanical means.

a) True
b) False

W.H.M.I.S.

(Workplace Hazardous Materials Information System)

Learning Objectives

After completing this section, you will be able to:

- List reasons behind the implementation of Workplace Hazardous Materials Information System (WHMIS).
- Identify the basic elements of WHMIS.

Describe the responsibilities of all the parties involved in the successful implementation of WHMIS.

Workplace Hazards

Several studies estimated a high social cost due to exposure to hazardous materials in the workplace. Due to the seriousness of such health & safety problems, it was agreed to implement an information system with the goal of reduced incidence of illnesses and injuries caused by the hazardous materials in the workplace.

The Workplace Hazardous Materials Information System (WHMIS) is a Canada-wide system developed over several years through the collective efforts of Labor, Industry, and Federal, Provincial, and Territorial Governments. Published in January 1988, it became legislation in October 1988.

The system consists of three key elements:

- cautionary labeling of containers of hazardous materials
- provision of Material Safety Data Sheet (MSDS), which provides more detailed information on the hazardous nature of the material

provision of worker education program

Safety Data Sheet

The Material Safety Data Sheet (MSDS) provides basic information on a chemical product.

It contains information regarding its:

- Properties
- Potential hazards
- Safe use
- Emergency procedures

It is important to note that these are not a complete source of information.

In some cases it might be necessary to consult other relevant sources for further information and details on a given substance.

Implementation

Worker Education

Workers handling hazardous products must be instructed in:

- The information on labels and MSDSs as it applies to their work
- Safe use, handling, storage and disposal of hazardous materials
- Emergency procedures to be used in case of a spill or overexposure

Successful Implementation Requirements

Successful implementation of WHMIS in the workplace requires cooperation of all parties involved. WHMIS sets the responsibilities of the parties involved:

- **Suppliers:** provide hazard information through labels and MSDS on all controlled products/containers of controlled products.
- **Employers (Supervisors)**: ensure WHMIS labels, identifiers and MSDSs for all containers of controlled products. Employers also ensure availability and accessibility of MSDS information to employees and provide effective worker training to ensure understanding among employees of the labels, MSDSs, and precautionary measures for hazardous materials in their workplace.
- **Employees:** handle controlled products safely and inform supervisors of damaged/missing labels and missing MSDS information.

Regulators: develop and administer WHMIS legislation.

GHS

The Globally Harmonized System (GHS) for Hazard Classification and Labelling

Systems similar to WHMIS (for hazard communication) exists in other countries.

In 1992, the United Nations Conference on Environment and Development (UNCED) agreed to develop a Globally Harmonized System (GHS) for hazard classification and labelling. It is anticipated that such a system will facilitate safe use of chemicals and reduce trade barriers.

Some of the anticipated changes are:

- Inclusion of consumer, transport and workplace sectors rather than workplace only.
- Inclusion of all chemicals except pharmaceutical and cosmetic products intended for consumer use.
- Hazard classification format in the MSDSs.

Hazard communication format in the labels.

The symbol for a potent carcinogen, one of the new symbols implemented by the GHS for substances hazardous to the human health (Source: UNECE website, Wikimedia)

Question

1. WHMIS was implemented with the goal of:

a) Reducing the incidence of illnesses and injuries caused by the hazardous materials in the workplace
b) Catching those who pollute the environment
c) Collecting more taxes
d) None of the answers apply

2. WHMIS was developed through the collective efforts of:

a) Labour and industry
b) Federal, provincial and territorial governments
c) Labour and the provincial government
d) None of the answers apply

3. The acronym WHMIS stands for:

a) Workplace Hazardous Materials Interaction System
b) Workplace Hazardous Medications Information System
c) Workplace Hazardous Materials Indexing System
d) None of the answers apply

4. The acronym WHMIS stands for:

a) Workplace Hazardous Materials Interaction System

b) Workplace Hazardous Materials Information System
c) Workplace Hazardous Materials Indexing System
d) None of the answers apply

5. In the implementation of WHMIS, suppliers must provide hazard information through:
a) Telephone calls
b) Emails
c) MSDSs only
d) Labels and MSDSs

6. In the implementation of WHMIS, suppliers must provide hazard information through:
a) Telephone calls
b) Emails
c) Labels only
d) None of the answers apply

7. MSDS provides information regarding:
a) Cost of the material
b) Delivery date for the material
c) Details on the hazardous nature of the material
d) None of the answers apply

8. Hazard information on all controlled products is provided through:
a) Telephone calls
b) Emails
c) Labels and MSDSs
d) None of the answers apply

9. In the workplace, employers must ensure availability and accessibility of MSDS information to employees.
a) True
b) False

10. In the successful implementation of WHMIS, regulators provide hazard information through labels and MSDSs.
a) True
b) False

Module Test:

Question

1. Workers have a right to:
a) Work in a safe and healthy environment
b) Know the processes and substances they are working with
c) Know the potential hazards from the substances and the processes
d) All of the answers apply

2. Confined space hazards arise due to:
a) Lack of hazardous materials
b) Ease of entry and exit
c) Oxygen deficiency
d) None of the answers apply

3. Potassium permanganate is an oxidizing material.
a) True
b) False

4. When handling a cylinder of compressed hydrogen gas (highly flammable) the worker is not only subjected to the chemical hazard but also the hazards associated with pressure extremes.
a) True
b) False

5. Workplace walk-through surveys are conducted to:
a) Meet the workers
b) Verify their ages
c) Pass the donuts around
d) Recognize the potential impact of workplace hazards

6. Which of the following agents/factors have the potential to adversely affect a worker's health and/or well being?
a) Physical, Chemical and Biological
b) Chemical and Biological
c) Chemical, Biological, Ergonomic
d) Physical, Chemical, Biological and Ergonomic

7. Which of the following statements is true for acute toxicity?
a) Results from brief exposure to high concentrations of the contaminant
b) Responses generally have latency periods
c) Responses are difficult to observe and relate
d) Results from low and repeated exposure over a long period of time

8. Which of the following statements is false for chronic toxicity?
a) Results from brief exposure to high concentrations of the contaminant
b) Responses generally have latency periods
c) Responses are difficult to observe and relate
d) Results from low and repeated exposure over a long period of time

9. Habit-forming depressants are classified as:
a) Asphyxiants
b) Anasthetics
c) Narcotics
d) Irritants

10. Hazard posed by sulfuric acid (a corrosive material) is classified as:
a) Ergonomic
b) Biological
c) Physical
d) Chemical

11. Which of the following statements is false?
a) Ozone causes eye, skin and mucous membrane irritation
b) Carbon monoxide is a carcinogen
c) Morphine is a narcotic
d) Asbestos is a lung scaring agent

12. Which of the following statements is true?
a) Vinyl chloride is a carcinogen
b) Ethylene oxide is a mutagen
c) Nitrous oxide is a teratogen
d) All of the answers apply

13. Chemical agents may be present in the air as:
a) Fine particles
b) Gases
c) Vapors
d) All of the answers apply

14. Chemical hazards may arise in operations involving:
a) Compressed gases
b) Corrosive materials
c) Combustible materials
d) All of the answers apply

15. Which of the followings is a biological agent that can cause illness in humans?
a) Ammonia
b) Bacteria
c) Hydrogen sulfide
d) All of the answers apply

16. Exposure to work-related biological agents is limited to:
a) Hospital workers
b) Meat packers
c) Veterinarians
d) All of the answers apply

17. A worker using a cylinder of highly flammable compressed gas is at a danger of being exposed to:
a) Physical hazard only
b) Biological hazard only
c) Chemical hazard only
d) None of the answers apply

18. A worker using a cylinder of highly corrosive compressed gas is at a danger of being exposed to:
a) Biological hazard only
b) Chemical hazard only
c) Physical hazard only
d) None of the answers apply

19. Many countries have agreed to develop a Globally Harmonized System for haza classification and labelling of hazardous materials in order to facilitate:
a) Safe use of chemicals
b) Price increase
c) Trade barriers
d) None of the answers apply

20. The Material Safety Data Sheet provides basic information on a chemical produ such as:
a) Price
b) Safe use

c) Availability
d) All of the answers apply

Module 5: Air and Water

Slide 2: Air

Learning Objectives

After completing this section, you will be able to:

- Explain the composition of air in terms of its major and minor components.
- Discuss the sources, some reactions and adverse health effects of minor components of air.
- Evaluate the process of risk assessment.

Slide 3: The Air We Breathe

Air (which all of us must breathe) composes the atmosphere and is a complex mixture of gases surrounding the Earth. The atmosphere is a layered structure divided into layers according to a variety of criteria such as gradually changing:

- Altitude
- Pressure
- Temperature
- Electrical nature
- Chemical composition and concentration

The Atmosphere

According to altitude, the atmosphere is divided into layers:

- 1. Troposphere (8-15)
- 2. Stratosphere (50)
- 3. Mesosphere (80 km)
- 4. Ionosphere/Thermosphere (500-600 km)

Right: Space Shuttle Endeavour straddling the stratosphere and mesosphere. The orange layer is the troposphere, where all of the weather and clouds, which we typically watch and experience, are generated and contained. This orange layer gives way to the whitish Stratosphere and then into the Mesosphere (Source: NASA/Crew of Expedition 22, Wikimedia)

Slide 4: The Composition of Air

The air we breathe is a mixture of several gases, fine particles and vapors. Dry air consists of 21% oxygen and 78% nitrogen plus traces of other substances that are both natural and human-made.

Major components of air:

- Nitrogen (N_2)
- Oxygen (O_2)
- Water (H_2O)
- Carbon dioxide (CO_2)

Some minor components of air:

- Carbon monoxide (CO)
- Ozone (O_3)
- Oxides of Sulfur (SO_x)
- Oxides of Nitrogen (NO_x)

Slide 5: The Air Pollutants

Whereas major components are essential for life, the minor components are pollutants, which under certain conditions may produce adverse environmental and health effects. These air pollutants are emitted directly into the atmosphere during combustion and production processes, changing the composition of atmosphere and causing poor air quality.

The burning of fossil fuels (i.e., petroleum, natural gas and coal) can be used:

- to generate energy (electricity, gas and steam)
- in transportation (combustion engines)

- in industrial processes that use a great deal of energy sources (i.e., pulp and paper mills, ore smelters, petroleum refineries, power generating stations and incinerators)

These elements are mainly responsible for the presence of minor components. That is, they are the major sources of human-created air pollution.

Slide 6: Minor Components

Air pollutants causing adverse environmental and health effects:

What is Carbon Monoxide?

With plenty supply of oxygen, there is a complete combustion fossils fuels thereby forming the major by products☹carbon dioxide and water). This process in immediately oxidized to carbon dioxide, however there insufficient supply of oxygen and there is a incomplete combustion of fossil fuels and carbon monoxide gas is released (desktop)

Slide 7: Assessing Health Risks

Entry into the Body

The air we breath (inhalation) is handled by the lungs, which provide an extremely efficient method of getting oxygen (required for metabolic processes) into and carbon dioxide (waste product of metabolic processes) out of the body.

Unfortunately, the lungs also provide an excellent opportunity for minor components (pollutants) to diffuse into the blood stream via gas exchange in the alveoli.

As breathing is a continuous process, considerable amounts of a pollutant (even if present as a minor component) can be inhaled and efficiently transported into the body. Once in the body, they may manifest adverse health effects.

Risk Assessment

In order to assess the health risks due to air pollutants, we require exposure and effects assessment.

- **Exposure assessment**: estimates concentrations using chemical

measurements.

- **Effects assessment:** relies on toxicity testing (estimates of exposure toxicity) and computer models to extrapolate data from human population, animal, and bacterial toxicity studies. Quantitative analysis of epidemiological, toxicological and exposure data that are based on the accurate scientific evidence estimates exposure toxicity and risk.

Risk characterization integrates the exposure and effects components to estimate the risk.

Slide 8:

Air

Exposure Measurement

Commonly used concentration units	
For gases and vapors:	**For particles:**
▪ Parts per million (ppm) ▪ Parts per billion (ppb) ▪ Percent (%)	▪ Milligrams per cubic meter (mg/m^3) ▪ Micrograms per cubic meter ($\mu g/m^3$)

Exposure is measured by determining the pollutant concentration in air. Monitoring methods include:

- Air sampling followed by laboratory analysis of the pollutant(s) using established procedures.
- Real time monitoring using direct reading pollutant-specific monitors.

Try these Examples

	Review: Dimensional Analysis in Module 2: The Scientific Method and Matter	Keep in mind these useful conversion factors: ▪ 1% = 10^4 ppm ▪ 1 ppm = 10^3 ppb

Example 1: A gas is toxic at a concentration of 500. ppm and any level of exposure above this value is considered unsafe for a worker. A real time monitor for the gas indicated a concentration of 0.0615% in a workplace environment. Is it safe to work in such an environment?

Click here for the answer.

Answer: (0.0615 parts gas/10^2 parts air) x 10^6 parts air = 615. ppm

It is not safe to work in such an environment.

Note: x% simply means x parts per hundred parts.

(click to hide)

Example 2: In an office environment, sampling and subsequent analysis for carbon monoxide (CO) indicated a concentration of 9.0 x 10^3 ppb. Express the concentration in the units of ppm and %.

Click here for the answer.

Answer: 1ppm = 1 x 10^3 ppb

(9.0 x 10^3 ppb) x (1ppm/1 x10^3 ppb) = 9.0 ppm

(9.0 x 10^3 parts CO/10^9 parts air) x 10^2 parts air = 9.0 x 10^{-4}%

(click to hide)

Slide 9:

Air

Threshold Limit Values

Thus, for pollutants, Threshold Limit Values (TLVs) have been developed and issued American Conference of Governmental Industrial Hygienists (ACGIH) to assist in th workplace health hazards.

According to ACGIH, Threshold Limit Value-Time-Weighted Average (TLV-TWA), is time-weighted average concentration for a normal 8-hour workday and a 40-hour w which nearly all workers may be repeatedly exposed, day after day, without advers

Substance	TLV-TWA
CO	25 ppm
NO_2	3 ppm
O_3	0.1 ppm
SO_2	2 ppm

Slide 10: Air Quality

Indoor Air contaminants:::

Asbestos fibers: mineral fiber has been used of building construction materials for insulating and fireproofing. Deteriorating, damaged or disturbed insulation, fireproofing. Become the source of asbestos fibers in the indoor air.

Biological contaminants: common biological include (bacteria, dust mites, insects, mold, pet dander, rodents, viruses).

Combustion by-product: these gases (carbon monoxide, carbon dioxide, nitrogen dioxide, unburned hydrocarbons) and small particles. They are completed by burning of fuels (wood, gas, coal) in appliances such as wood stoves, gas stove, and fireplaces.

Formaldehyde: the sources of formaldehyde in indoor air include: pressed wood product such as hardwood plywood wall paneling, particleboard, fiberboard,, furniture made with these pressed wood products, combustion sources, tobacco smoke, textiles and glues.

Pesticides: originate from the products used to kill household pest (insecticides, disinfectants) pesticides used on lawns and gardens can drift or tracked indoors.

Radon gas: slowly releases from the ground water and some buildings that contain small amounts of uranium (concrete, bricks, tiles)
Radon can enter a house through cracks in the foundation walls and in floor slabs, floor drains, and sumps

Respirable particles: depends on size these can be inhaled into the lungs. Indoor resources such: fireplaces, wood stoves. Oil heaters, tobacco smokes.

Volatile organic compounds (VOC's) these compounds originate from a variety of indoor sources such as air fresheners, aerosol sprays, disinfectants, dry-cleaned clothing, hobby supplies, paints, solvents.

Slide 11:

Air

Control Strategies

North American Agreement (orthographic projection) (Source: Heraldry, Wikimedia)

Over the past two decades, stricter environmental emission control regulations and pollutant(s) mitigation (reduction) technologies have led to considerable reduction in the concentration of many pollutants.

The North American Free Trade Agreement (NAFTA) obliges all the three signatories to enforce environmental laws. There is a move in all the three nations toward tougher and thorough reporting of releases of pollutants to the environment. In Canada, National Pollutant Release Inventory (NPRI) is a publicly-accessible database of pollutants released to the Canadian environment.

Among the global initiatives is the establishment of the International Register of Potentially Toxic Chemicals (IRPTC). It is a computer based database. One of the objectives of the register is to identify the potential hazards of using chemicals and to make people aware of them. The database provides access to information regarding production, distribution, release and disposal of hazardous chemicals. The database also includes information on environmental and health effects of such chemicals.

Interested in learning more check out these suggested links:

- Canada and the North American Free Trade Agreement from Foreign Affairs and International Trade Canada
- National NAFTA office a site jointly produced by the governments of Canada, the United States and Mexico
- National Pollutant Release Inventory: Tracking Pollution in Canada from Environment Canada
- Reasons and effects of air pollution from chris 論

Slide 12:

Air

What have you learned?

The self assessment for this section will help you with your graded quizzes, cumulative tests and final exam. The content in this self-assessment comes from a randomized bank of questions, which means that every time you click the left hand menu—on the title "What have you learned?"—you will be provided with a new set of questions.

Select the best answer by clicking on it. Click on the **Next** button to move on to the next question.

<%@Register tagprefix="ec" Tagname="QuizTest"
src="../_lib/controls/SelfAssessment.ascx" %>

Slide 13: Water

Learning Objectives

After completing this section, you will be able to:

- Describe the bonding and structure of water.
- Discuss the unique properties of water in terms of its polar nature and hydrogen bonding capability.
- Evaluate the role such unique properties play in making water essential for life and in determining its behavior in the environment.

Keyterms

Use the Glossary (top menu bar) to check out these terms

▪ hydrogen bonds ▪ electronegativity ▪ dipole	▪ intermolecular attractive forces ▪ solvent	▪ specific heat ▪ surface tension ▪ Capillary action

Slide 14:

Water

The Water Molecule

Water (H_2O) consists of two nonmetals hydrogen and oxygen. The water molecule i
covalent bonding of two hydrogen atoms to an oxygen atom. Water is a unique sub
everywhere. A vital substance to our well-being and very existence, water is intima
life.

Unique properties of water

The polar nature and the capability to form hydrogen bonds are responsible for many of the unique properties of water. Such properties play an

We use water for various purposes, such

▪ Cooking and Drinking ▪ Personal hygiene ▪ Recreation	▪ Agriculture ▪ Transportation ▪ Energy generation

important role in making water essential for life and in determining its chemical behavior in the environment.

Slide 15:

Water

Polarity of Water

The polar nature of the water molecule is due to its:

- Polar covalent bonds: The electron pair forming the covalent bond (between the oxygen atom and each of the two hydrogen atoms) is more strongly attracted by the oxygen atom due to its higher electronegativity (the ability of an atom in a molecule to attract shared electrons over another atom in the molecule).
-
- This leads to a partial positive charge on each of the two hydrogen atoms (represented as $^{+}$) and a partial negative charge on the central oxygen atom (represented as $^{-}$) making the water molecule behave like a dipole.
-
- Molecular shape: A water molecule has a bent (V-shape) shape (H-O-H bond angle of 104.5°). This, in combination with the polar covalent bonds, leads to a resultant dipole and hence the polarity of the water molecule.

Slide 16:

Water

Hydrogen Bonding

The partial charges present lead to intermolecular attraction between water molecules. A single water molecule can thus attract four other water molecules.

These intermolecular attractive forces are called hydrogen bonds. These are much weaker than the forces holding the atoms in the covalent O-H bond.

Slide 17:

Water

Solvent Properties

Water is a powerful solvent due to its high polarity and hydrogen bonding ability.

It is an excellent solvent for ionic (e.g., table salt), polar covalent (e.g., sugar) and non-polar (e.g., oxygen) compounds. In the case of ionic compounds, the ions are separated from the solid and caged (solvated) by polar water molecules, thus keeping them in solution.

Click on ir

Polar covalent compounds (i.e., ethanol and glucose) dissolve in water by the formation of hydrogen bonds.

Water therefore plays an important role in the transportation of nutrients and waste products in biological processes. Aquatic life and plants survive due to dissolved oxygen and carbon dioxide.

Slide 18:

Water

Thermal Properties

Steam and liquid water are two different forms of the same chemical substance, water (Source: Markus Schweiss, Wikimedia)

The presence of hydrogen bonds in water accounts for its exceptionally high boiling point, specific heat and heat of vaporization. A portion of the heat supplied is used up in breaking the hydrogen bonds.

Specific heat is defined as the amount of heat energy required to increase the temperature of 1 g of a substance by 1°C.

High specific heat of water regulates and stabilizes the

temperatures of geographical regions and organisms within a narrow range. This in turn allows our planet to support life.

Heat of vaporization is defined as the quantity of heat required for the conversion of 1 g of a liquid entirely into its vapor at a constant temperature. High heat of vaporization of water helps in regulating the temperature of our body. It is also responsible for powering the winds and storms of our planet.

Slide 19:

Water

Water Density

Density of Solid and Liquid Water

Solid (ice) and liquid form of (water) - hexagonal open structure due to the presence of hydrogen bonds

Ice has a hexagonal open structure due to the presence of hydrogen bonds. When ice melts, the open spaces are filled with liquid water, causing the crystal structure to break down.

This leads to a reduction in volume for the same mass and hence an increase in density (density = mass/volume). The higher density (thus expansion and contraction of volume due to the freeze-thaw cycle) of liquid water than that of ice accounts for phenomena such as:

- Floating of ice on water
- Survival of aquatic life during winter
- Nutrient turnover in bodies of water
- Formation of pebbles, soil and sand
- Bursting of frozen water pipes

Slide 20:

Water

Surface Properties

The high **surface tension** and capillarity of water is due to the presence of hydrogen bonds. Water is the liquid with the highest

surface tension. Plant debris rests (rather than sinks) on the surface of water bodies due to its high surface tension. This provides aquatic life with much-needed shelter and nutrients. **Capillary action** (also due to high surface tension) makes water in soil available to plants.

Suggested Viewing

Capillary Effect

- On Earth, the capillary effect can be seen in fine tubes containing liquid: surface tension pulls the liquid column up until there is a sufficient mass of liquid for gravity to overcome the intermolecular forces. As the mass of the liquid column is proportional to the square of the tube's diameter, a narrow tube will draw a liquid column higher than a wide tube. In space, many things work differently, but not always (Length: 9:30, YouTube).

Surface Tension: The Pepper Scatter Experiment

We experiment how a property of water, surface tension, actually works (Length 2:27, YouTube).