THE MATERIAL WORLD

SUMMARY

COMPULSORY CONCEPTS OF THE ENVIRONMENTAL SCIENCE AND TECHNOLOGY (EST) PROGRAM

Chapter	Concept review	Compulsory concepts
Chapter 1	Atoms and atomic models (p. 3)	Rutherford-Bohr atomic model, neutron, simplified atomic model
	The periodic table (p. 7)	Groups and periods, relative atomic mass, atomic number, periodicity of properties, isotopes
	Representing atoms (p. 13)	Rutherford-Bohr atomic model, simplified atomic model, Lewis notation
	The concept of mole (p. 15)	Concept of mole, Avogadro's number
Chapter 2	Molecules and ions (p. 21)	Ions, polyatomic ions, types of bonds (covalent, ionic)
	The rules of nomenclature and notation (p. 25)	Nomenclature and notation rules
	Solubility and concentration (p. 27)	Concentration (ppm, mol/L)
	Electrical conductivity and pH (p. 31)	Electrical conductivity, electrolytes, electrolytic dissociation, strength of electrolytes, salts, pH scale
Chapter 3	Energy and energy efficiency (p. 39)	Law of conservation of energy, energy efficiency
	Thermal energy (p. 41)	Distinction between heat and temperature; relationship between heat energy, specific heat capacity, mass and temperature variations
	Kinetic energy, potential energy and mechanical energy (p. 43)	Relationship between kinetic energy, mass and velocity; relationship between potential energy, mass, acceleration and travel
	Motion and types of force (p. 45)	Relationship between mass and weight
	Effective force and work (p. 47)	Effective force, relationship between work, force and travel; relationship between work and energy
Chapter 4	Balancing chemical equations (p. 53)	Law of conservation of mass, balancing chemical equations, stoichiometry
	Endothermic and exothermic reactions s (p. 61)	Endothermic and exothermic reactions
	Chemical changes (p. 65)	Oxidation, combustion, photosynthesis and respiration, acid-base neutralization reaction
	Nuclear transformations (p. 69)	Nuclear stability, radioactivity, fission and fusion
Chapter 5	Electricity and electrical charges (p. 75)	Electrical charge, electrical field
	Static electricity (p. 77)	Static electricity, Coulomb's law
	Electric current and electrical power (p. 79)	Ohm's law, relationship between power and electrical energy
	Electrical circuits (p. 83)	Electrical circuits, Kirchhoff's laws
	Magnetism and electromagnetism (p. 89)	Magnetic forces of attraction and repulsion, magnetic field of a live wire, magnetic field of a solenoid

Name: _____ Class: _____ Date: _____

Atoms and atomic models

PAGES 6 TO 17

CONCEPT REVIEW 1
Complete this concept review handout and keep it as a record of what you have learned.

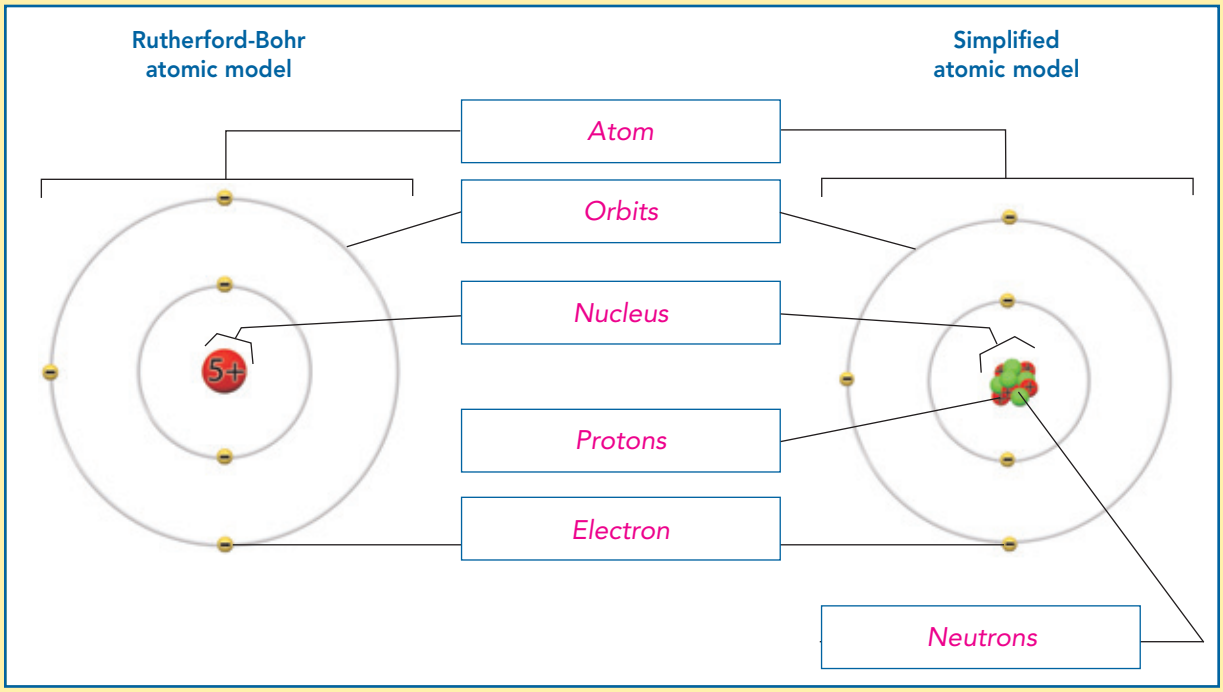
Definitions

- An atom is *the smallest particle of matter. It cannot be divided chemically.*
- The electron is *one of the particles that make up an atom. It is negatively charged.*
- The proton is *one of the particles that make up an atom. It is found in the nucleus and carries a positive charge.*
- The neutron is *one of the particles that make up an atom. With the proton, it forms the nucleus. It has no electrical charge, so it is neutral.*

Characteristics of atomic particles

Particle	Symbol	Electrical charge	Mass (g)	Mass (u)
Electron	e^-	*Negative*	9.109×10^{-28}	0.000 55
Proton	p^+	*Positive*	1.673×10^{-24}	1.007
Neutron	n	*Neutral*	1.675×10^{-24}	1.008

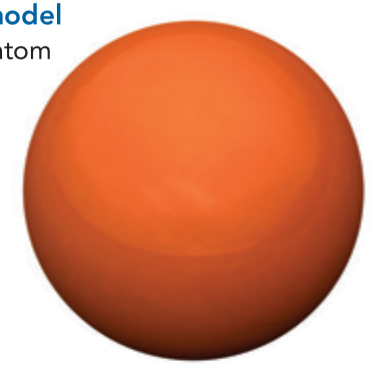
Parts of the atom



Evolution of the atomic model

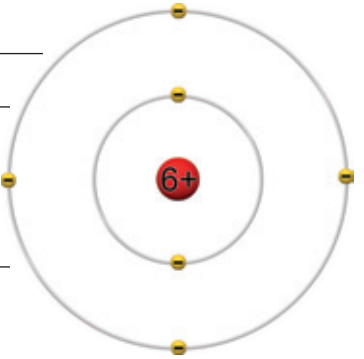
1808 Dalton's atomic model

According to Dalton, the atom is like a billiard ball—solid and indivisible.



1913 Rutherford-Bohr atomic model

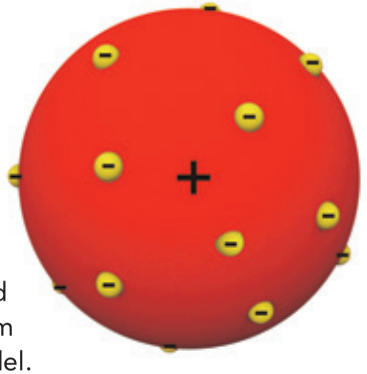
Bohr modified Rutherford's atomic model by describing the orbits in which electrons move.



1800 1810 1820 1830 1840 1850 1860 1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010

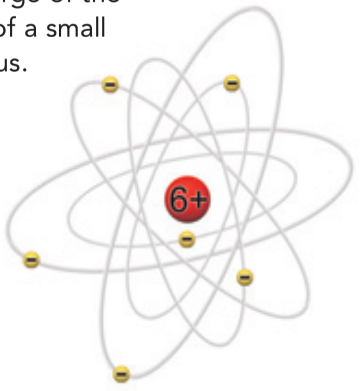
1897 Thomson's atomic model

Thomson modified Dalton's atomic model by describing the atom as a positively charged ball embedded with small negatively charged particles, namely, electrons. Thomson's version is often referred to as the plum pudding model.



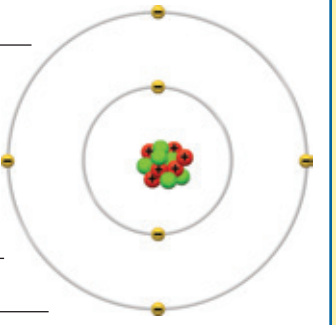
1911 Rutherford's atomic model

Rutherford modified Thomson's atomic model by imagining the entire positive charge of the atom in the form of a small but massive nucleus. The negatively charged electrons circle the nucleus.



After 1932 Simplified atomic model

The simplified atomic model refines the Rutherford-Bohr model by adding the neutron, discovered by Chadwick.



Name: Class: Date:

Name: _____ Class: _____ Date: _____

INTEGRATION QUESTIONS

Atoms and atomic models

1. What am I?

a) I am a representation of the atom. *An atomic model.*

b) I am an area in which electrons circulate. *An orbit.*

c) I am the lightest particle in the atom. *The electron.*

d) I contain positive and neutral particles. *The nucleus.*

e) I am an atomic model that shows the three particles of the atom. *The simplified atomic model.*

2. Find the two false statements and correct them.

A. The nucleus of an atom is made up of electrons.
B. A proton's charge is positive.
C. Electrons can change their orbits.
D. An atom cannot be divided chemically.
E. The symbol for electron is "e^+".
F. All matter is made up of atoms.

The two false statements are A (The nucleus of an atom is made up of positively charged particles: protons and neutrons.) and E (The symbol for electron is "e^-.").

3. Why is an atom electrically neutral?

Because it contains as many positive particles (protons) as negative particles (electrons), cancelling the charges.

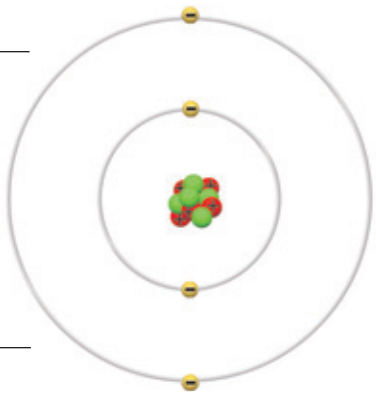
4. What is the difference between the Rutherford-Bohr atomic model and the simplified atomic model?

The simplified atomic model refines the Rutherford-Bohr atomic model by showing the neutrons contained in the nucleus.

5. Why do alpha rays, which are positive, deflect when they hit an atom's nucleus?

Because the nucleus contains protons—particles that carry positive charges—and identical charges repel each other.

6. What is the error in this representation of the atom?



The atom does not contain the same number of protons (5) as electrons (4).

Name: _____ Class: _____ Date: _____

7. Associate each of the following statements with the model it refers to.

a) It includes electrons for the first time.

b) In this, the orbits in which electrons move appear.

c) It shows the atom as an indivisible ball.

d) It contains the atom's three particles.

e) It includes an atomic nucleus for the first time.

A. Dalton's atomic model

B. Thomson's atomic model

C. Rutherford's atomic model

D. Rutherford-Bohr atomic model

E. Simplified atomic model

8. What is the role of the neutrons?

They hold the protons together.

9. What was Bohr's contribution to the Rutherford model?

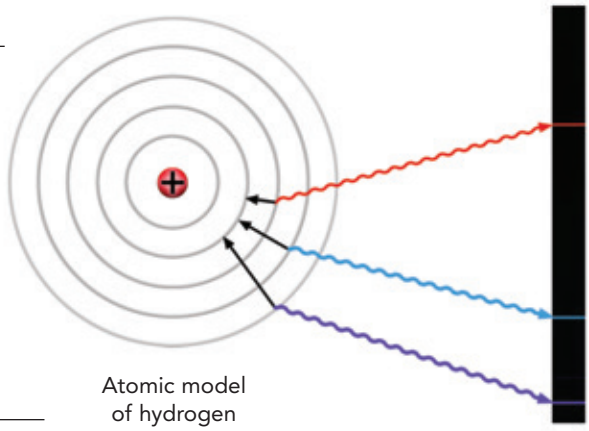
Bohr discovered that electrons do not randomly move around the nucleus, but instead have specific orbits.

10. Why has the atomic model evolved over the years?

To reflect the most recent discoveries on matter.

11. Why do elements emit light of a specific colour when heated? Use the illustration to support your explanation.

When an element is heated, its electrons are supplied with electricity. They become "excited" and jump to an orbit farther from the nucleus than their original orbit. The electrons then return to their original orbit emitting the energy received in the form of light. Each jump of an orbit corresponds to a specific wavelength, and thus to a specific colour. For example, the hydrogen atom emits a red light when it jumps from orbit 3 to orbit 2.



Atomic model of hydrogen

Emission spectrum of hydrogen

Name: _____ Class: _____ Date: _____

The periodic table

PAGES 17 TO 26

CONCEPT REVIEW 2

Complete this concept review handout and keep it as a record of what you have learned.

Definitions

- The periodic table of the elements is *a visual presentation of the elements in groups according to their physical and chemical properties.*
- A valence electron is *an electron in the outermost shell of an atom.*
- A group corresponds *to a column of the periodic table. The elements in a particular group have similar chemical properties because they all have the same number of valence electrons.*
- A period corresponds *to a row of the periodic table. All the elements in a period have the same number of electron shells.*
- The periodicity of properties is *the repetition of patterns in properties from one period to another.*
- The atomic number represents *the number of protons in the nucleus of an atom. It distinguishes one element from another.*

  Symbol: *Z*
- The relative atomic mass is *the mass of an atom measured by comparison with a reference element, carbon-12.*

  Unit of measurement: *Atomic mass unit.* Symbol of the unit of measurement: *u*
- An isotope is *an atom of an element with the same number of protons as another atom of the same element but with a different number of neutrons.*

Representing atoms with the $^{A}_{Z}E$ notation

Name: *Mass number*
Whole number indicating the sum of the numbers of protons and neutrons in an atom. It is found by rounding the relative atomic mass to the nearest whole number.

$^{A}_{Z}E$

Name: *Symbol of an element*

Name: *Atomic number*

To find the number of neutrons in an atom: *subtract Z from A.*

Name: _____ Class: _____ Date: _____

Properties of the categories of elements

Category (location)	Properties
Metals (to the left of the staircase)	• *Good conductors of electricity and heat.* • *Ductile and malleable.* • *Usually shiny.* • *Solid at room temperature (except mercury).* • *Many react with acids.*
Nonmetals (to the right of the staircase, except hydrogen)	• *Generally poor conductors of electricity and heat.* • *Many are gases at room temperature.* • *When solid, they can easily be reduced to powder.*
Metalloids (or semimetals) (on both sides of the staircase)	• *Properties depend on conditions.*

Properties of certain groups of elements

Group (location)	Properties
Alkali metals (1st column)	• *Soft and highly reactive metals.* • *In their pure state, they must be stored in oil.* • *They do not exist in their elemental state in nature.*
Alkaline earth metals (2nd column)	• *Highly malleable and reactive metals. They burn easily.* • *They can be exposed to air.* • *They form many compounds found in rocks or earth.* • *They do not exist in their elemental state in nature.*
Halogens (penultimate column)	• *Nonmetals.* • *Many are powerful disinfectants.* • *They react easily to form compounds, including salts.*
Noble gases (last column)	• *Nonmetals.* • *Very stable gases: they react minimally with other elements.* • *They exist in their elemental state in nature.*

Name: _____ Class: _____ Date: _____

INTEGRATION QUESTIONS

The periodic table

You will need the periodic table on the inside cover of this book to answer some of the following questions.

1. True or false? If a statement is false, correct it.

a) All alkaline earth metals have two valence electrons.

True.

b) Metalloids are always good conductors of electricity.

False. They are sometimes good conductors and sometimes poor conductors, depending on conditions.

c) A period corresponds to a column of the periodic table.

False. It corresponds to a row.

d) The atomic number represents the number of neutrons in the atom.

False. It represents the number of protons.

e) All the isotopes of an element have the same chemical properties.

True.

2. How many valence electrons do each of the following elements have?

a) Calcium *2*

b) Sulphur *6*

c) Sodium *1*

d) Fluorine *7*

e) Potassium *1*

f) Xenon *8*

3. Complete the following table.

Element	Chemical symbol	Atomic number	Relative atomic mass (u)
Gold	*Au*	*79*	*196.97*
Bromine	*Br*	*35*	*79.90*
Nitrogen	*N*	*7*	*14.01*
Copper	*Cu*	*29*	*63.55*
Mercury	*Hg*	*80*	*200.59*
Uranium	*U*	*92*	*238.03*
Lithium	*Li*	*3*	*6.94*
Magnesium	*Mg*	*12*	*24.31*
Potassium	*K*	*19*	*39.10*

Name: _____ Class: _____ Date: _____

4. Which element is being described?

a) It has seven valence electrons in its fifth electron shell. *Iodine.*

b) It is an alkali metal with six electron shells. *Cesium.*

c) It has three valence electrons and is a metalloid. *Boron.*

d) It is very stable and it has four electron shells. *Krypton.*

e) It is the metal with the smallest atomic number. *Lithium.*

5. Give some characteristics of the following elements based on their place in the periodic table.

a) Potassium.

It belongs to the alkali metal family because it is in the first column (one valence electron). It is therefore a soft, highly reactive metal. It has four electron shells because it is in the fourth row of the periodic table.

b) Xenon.

It is a rare gas because it is in the last column (eight valence electrons). It is therefore very stable and does not react with other elements. It has five electron shells because it is in the fifth row.

c) Fluorine.

It is a halogen because it is in the second-last column (seven valence electrons). It is a non-metal that reacts easily to form compounds. It has two electron shells because it is in the second row.

6. Find the number of neutrons possessed by each of the following elements.

a) ${}^{16}_{8}O$ *8 neutrons.*

b) ${}^{39}_{19}K$ *20 neutrons.*

c) ${}^{59}_{27}Co$ *32 neutrons.*

7. Represent the following elements with an ${}^{A}_{Z}E$ formulation.

a) Beryllium ${}^{9}_{4}Be$

b) Radium ${}^{226}_{88}Ra$

c) Bismuth ${}^{209}_{83}Bi$

8. What am I?

a) I have 82 protons and 82 electrons.

Lead.

b) My mass number is 12.

Carbon (or carbon 12).

c) My symbol is Cu.

Copper.

d) I am an atom of an element with a different number of neutrons from another atom of the same element.

An isotope.

9. An atom has 26 protons and 30 neutrons. Indicate whether the following statements about this atom are true or false. Correct them if necessary.

a) This element is iron.

True.

b) This element has 30 electrons.

False. It has 26 electrons.

c) Its nucleus contains 30 particles.

False. It contains 56 particles (30 neutrons plus 26 protons).

10. An atom has 28 protons and 31 neutrons.

a) How many electrons does it have? *28 electrons.*

b) What is its mass number? *59.*

c) What is its atomic number? *28.*

11. How can the different isotopes of a same element be recognized with ${}^{A}_{Z}E$ notation?

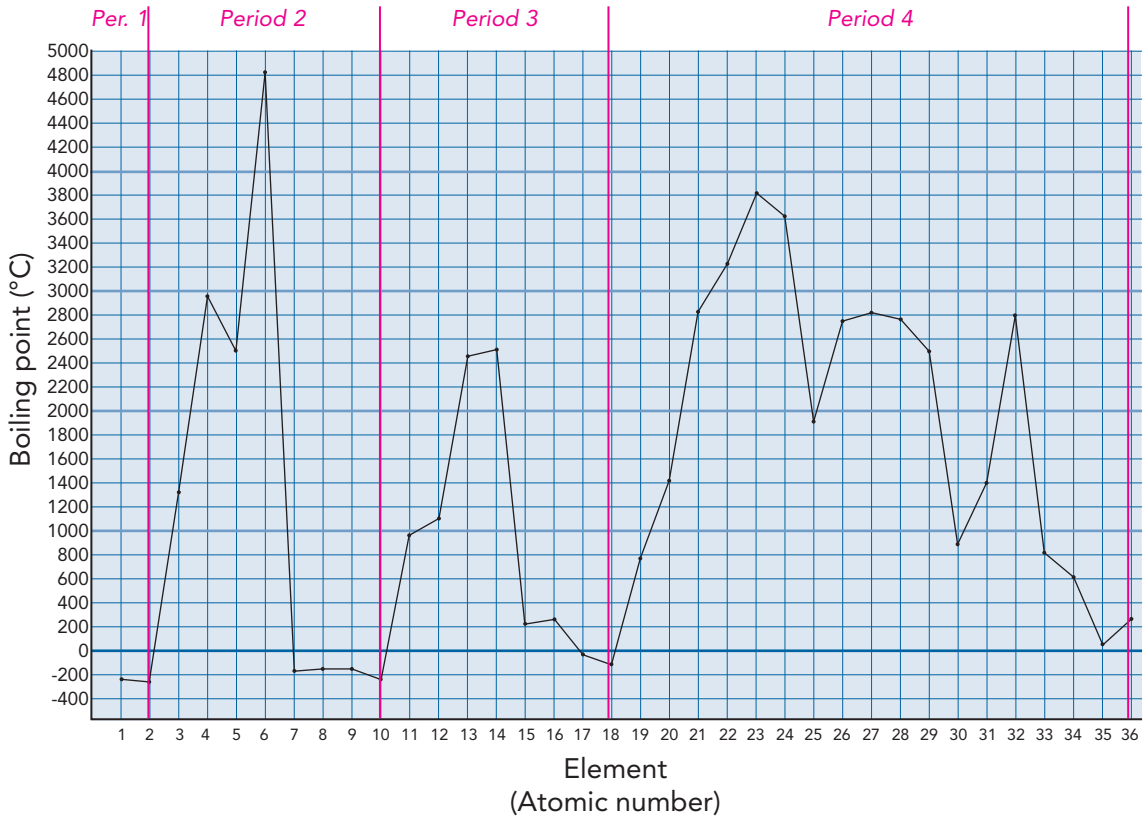
They all have the same atomic number (Z), but their mass number (A) is different.

12. What is the difference between carbon 12 and carbon 14?

Carbon 14 has two neutrons more than carbon 12.

Name: _____ Class: _____ Date: _____

13. In the following graph, identify the different periods and show where they begin and end.



14. Using the graph in the previous question, describe how the boiling point varies within a period.

The boiling point follows a cycle of increase and decrease within a period.

15. Complete the following table.

Element	Number of protons	Number of electrons	Number of neutrons
Aluminum	*13*	*13*	*27 – 13 = 14*
Arsenic	*33*	*33*	*75 – 33 = 42*
Carbon	*6*	*6*	*12 – 6 = 6*
Helium	*2*	*2*	*4 – 2 = 2*
Iodine	*53*	*53*	*127 – 53 = 74*
Magnesium	*12*	*12*	*24 – 12 = 12*
Radium	*88*	*88*	*226 – 88 = 138*

Name: _____ Class: _____ Date: _____

Representing atoms

PAGES 26 TO 29

CONCEPT REVIEW 3

Complete this concept review handout and keep it as a record of what you have learned.

Four ways of representing atoms

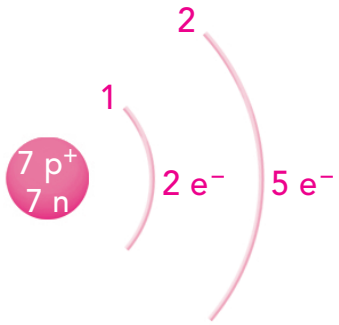
- *Lewis notation*

Simplified representation of the atom, in which only the valence electrons are illustrated.

Nitrogen

- *Simplified atomic model*

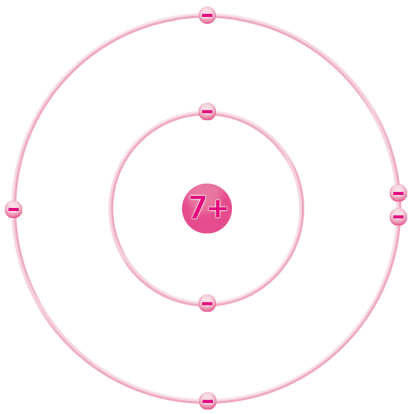
Representation of the atom showing the number of protons and neutrons. It also shows the number of electrons in each shell.



Nitrogen

- *Rutherford-Bohr atomic model*

Representation of the atom showing the number of protons, electrons and electron shells.



Nitrogen

- *"Ball-and-stick" atomic model*

Representation in which the atom is depicted as a ball, and its bonds with other atoms are shown with sticks. The size of the ball is generally proportional to the number of electron shells in the atom.

Nitrogen

Name: _____ Class: _____ Date: _____

INTEGRATION QUESTIONS

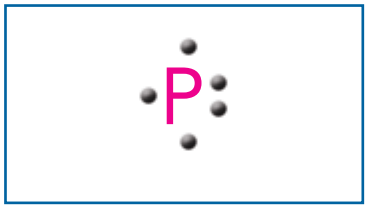
Representing atoms

You will need the periodic table on the inside cover of this book to answer some of the following questions.

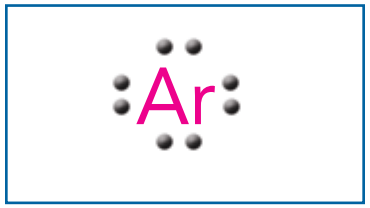
1. Draw a Lewis structure for each of the elements below.

a) Sodium.

b) Phosphorus.

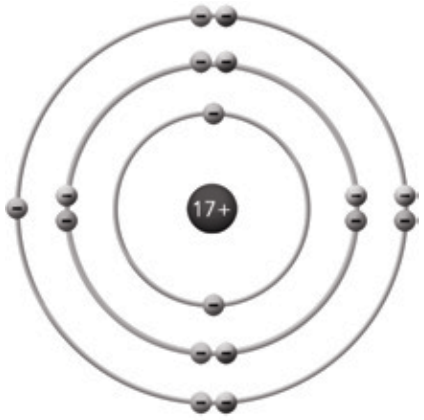


c) Argon.



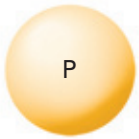
2. Explain the stages involved in representing a chlorine atom according to the Rutherford-Bohr atomic model. Draw it.

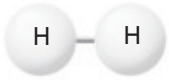
- *Chlorine has three electron shells because it is in the third period of the periodic table.*
- *Chlorine has seven valence electrons because it belongs to Group VII A.*
- *The atomic number of chlorine is 17; it therefore has 17 protons and 17 electrons.*



Chlorine

3. Name the atoms and molecule below.





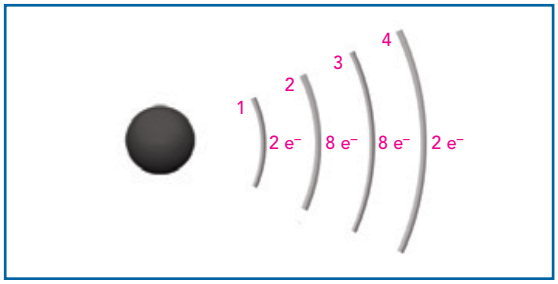
a) *Helium.*

b) *Phosphorous.*

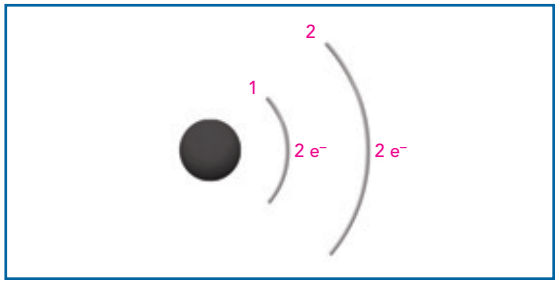
c) *Hydrogen (H_2).*

4. Represent the following elements using the simplified atomic model.

a) Calcium.



b) Beryllium.



Name: _____ Class: _____ Date: _____

The concept of mole

PAGES 30 TO 31

CONCEPT REVIEW 4

Complete this concept review handout and keep it as a record of what you have learned.

Definitions

- A mole is *a quantity equal to the number of atoms in exactly 12 g of carbon-12.*

  Symbol: *mol*
- The molar mass of a substance is *the mass of one mole of that substance.*
- Avogadro's number represents *the number of entities in a mole. It equals 6.02×10^{23}.*

Mathematical formula and units of measurement for molar mass

$$M = \frac{m}{n}$$

where M *is the molar mass (in g/mol).*

m *is the mass (in g).*

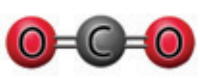
n *is the number of moles (in mol).*

Some examples of molar mass

Substance	Relative atomic mass (u)	Molar mass (g/mol)
Oxygen	16,00	16,00
Potassium	*39,10*	*39,10*
Silicon	*28,09*	*28,09*
Argon	*39,95*	*39,95*
Lithium	*6,94*	*6,94*
Carbon dioxide (CO_2)	*C = 12,01* *O = 16,00*	*12,01 + (2 × 16,00) = 44,01*

Graphic representation of the relation between a substance's relative atomic mass and its molar mass

Microscopic scale



A molecule of CO_2
(44.01 u)

Macroscopic scale

A mole of CO_2
(44.01 g)

Name: _____ Class: _____ Date: _____

INTEGRATION QUESTIONS

The concept of mole

You will need the periodic table on the inside cover of this book to answer some of the following questions.

1. Calculate the number of moles…

a) in 72 g of molecular nitrogen (N_2). *2.57 mol*

b) in 200 g of aluminum. *7.41 mol*

c) in 10 g of molecular hydrogen (H_2). *4.95 mol*

d) in 2 kg of uranium. *8.40 mol*

e) in 0.5 kg of iron. *8.95 mol*

f) in 20 g of phosphorus. *0.65 mol*

2. Convert the following data into moles.

a) 2.408×10^{24} oxygen atom. *4 mol of oxygen atoms.*

b) 6.02×10^{25} iodine atoms. *100 mol of iodine atoms.*

c) 3.01×10^{23} nickel atoms. *0.5 mol of nickel atoms.*

d) 3.7926×10^{24} steel balls. *6.3 mol of steel balls.*

e) 9.3912×10^{25} candies. *156 mol of candies.*

f) 1.5652×10^{23} diamonds. *0.26 mol of diamonds.*

3. If a thermometer contains 0.03 mol of mercury, what would that represent in grams?

$m = M \times n = 200.59\ g/mol \times 0.03\ mol = 6.02\ g$

It represents 6.02 g of mercury.

4. If you won 4.5×10^{-18} mol dollars, how many dollars would that represent?

$(\$4.5 \times 10^{-18}\ mol) \times (\$6.02 \times 10^{23}/mol) = \$2\ 709\ 000$

It represents $2 709 000.

5. Steel is 98 percent iron and 2 percent carbon. What is the mass of one mole of steel?

Mass of iron: $m = M \times n = 55.85\ g/mol \times 0.98\ mol = 54.73\ g$

Mass of carbon: $m = M \times n = 12.01\ g/mol \times 0.02\ mol = 0.24\ g$

$54.73\ g + 0.24\ g = 54.97\ g$ of steel

One mole of steel has a mass of 54.97 g.

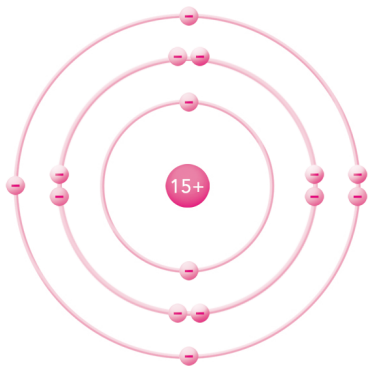
Name: _____ Class: _____ Date: _____

ADDITIONAL QUESTIONS

- **Atoms and atomic models** • **The periodic table**
- **Representing atoms** • **The concept of mole**

You will need the periodic table on the inside cover of this book to answer some of the following questions.

1. Using the Rutherford-Bohr atomic model, draw an atom with three electron shells and five valence electrons. Don't forget to name the element.



Element: *Phosphorous*

2. Which element is being described?

a) I am a metal. I burn easily in the presence of heat. I am found in rocks. I do not need to be stored in oil in the pure state. I have three electron shells.

Magnesium.

b) I have a mass of 1.66×10^{-24} g.

Hydrogen.

3. With which atomic model can mass number be deduced? Explain your answer.

The simplified atomic model because it shows the number of neutrons.

4. Why are the noble gases very stable?

The last electron shell is complete, which makes them unlikely to give off or gain electrons.

5. Fred must fill his little brother's pool. His mother, who is a chemist, tells him to put 18 600 mol of water in it. How many litres of water must Fred pour into the pool if a litre of water has a mass of 1 kg?

Molar mass of water: $(2 \times 1.01) + 16.00 = 18.02$ g/mol

Mass of water: $m = M \times n = 18.02 \text{ g/mol} \times 18\,600 \text{ mol} = 335\,172$ g

335 172 g ≃ 335 kg ≃ 335 L

Fred must use approximately 335 L of water to fill his little brother's pool.

Name: _____ Class: _____ Date: _____

6. What is the advantage of molar mass over relative atomic mass?

Molar mass measures macroscopically rather than microscopically.

7. Complete the following table.

Mass (g)	Number of moles (mol)	Molar mass (g/mol)	Element
107.92	4	*26.98*	*Aluminium*
40.12	0.2	*200.60*	*Mercury*
1.95	0.01	*195.00*	*Platinum*
2 253 833.48	250 148	*9.01*	*Beryllium*

8. How can electrical conductivity vary within a period? Explain your answer.

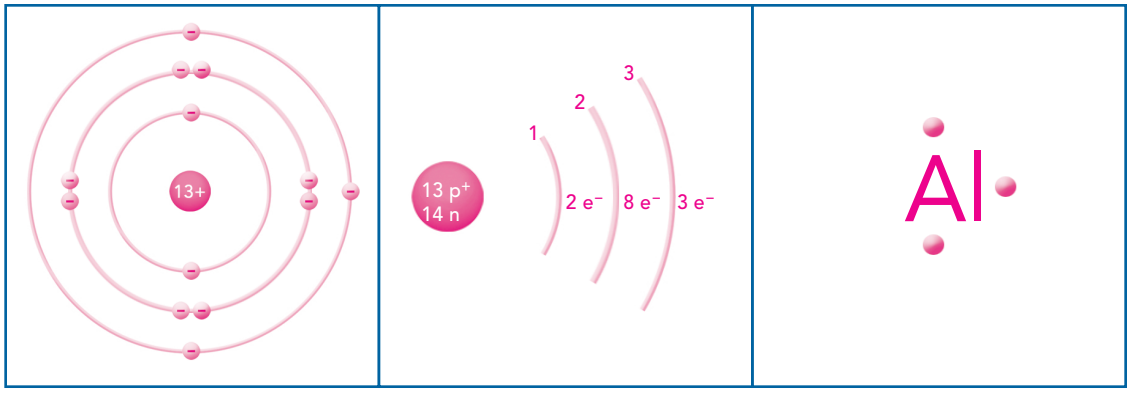
Electrical conductivity will be relatively high at the beginning of a period because metals are good conductors. It will then become very weak at the end of a period because non metals are poor conductors.

9. Draw an aluminum atom according to the following representations.

a) Rutherford-Bohr atomic model

b) Simplified atomic model

c) Lewis notation



10. Of the representations you drew in the previous question, which would you use to illustrate an isotope other than aluminum? Explain your answer.

The simplified atomic model because it is the only one that shows the number of neutrons in the nucleus.

11. At the hospital, a patient is connected to an aqueous solution of glucose ($C_6H_{12}O_6$). She receives 0.05 mol of glucose every minute. If her treatment lasts 25 minutes, how many grams of glucose will she receive in all?

Molar mass of glucose: (6 × 12.01) + (12 × 1.01) + (6 × 16.00) = 180.18 g/mol

0.05 mol/min × 25 min = 1.25 mol

Mass of glucose: m = M × n = 180.18 g/mol × 1.25 mol = 225.23 g

The patient will receive 225.23 grams of glucose in all.

12. Karen and Melissa have each inherited precious metals. Karen received 21 500 mol of silver and Melissa 196 mol of gold. Each says she would become a millionaire by selling her inheritance by weight. Are they correct, considering that the current price of gold is $25 797.76/kg and that of silver $464.90/kg?

Mass of silver: m = M × n = 107.87 g/mol × 21 500 mol = 2 319 205 g = 2319.2 kg

Mass of gold: m = M × n = 196.97 g/mol × 196 mol = 38 606.12 g = 38.6 kg

Value of silver: 2319.2 kg × $464.90/kg = $1 078 196.08

Value of gold: 38.6 kg × $25 797.76/kg = $995 793.54

Only Karen is correct because the value of her inheritance exceeds one million dollars.

13. A salt water aquarium contains 30 g of salt (NaCl) per litre of water. How many moles of salt does it contain if its capacity is 30 L?

30 g/L × 30 L = 900 g of salt

Molar mass of NaCl: 22.99 g/mol + 35.45 g/mol = 58.44 g/mol

$$n = \frac{m}{M} = \frac{900\ g}{58.44\ g/mol} = 15.4\ mol$$

The aquarium contains 15.4 mol of salt.

Name: _____ Class: _____ Date: _____

14. Alex is prone to exaggeration. He says that he has cut his hand with a knife and wants to call an ambulance because he has lost 3500 x 10^{-27} drops of blood. Is he being needlessly dramatic? Explain your answer.

(3500 × 10^{-27} mol of drops of blood) × (6.02 × 10^{23} drops of blood/mol of drops of blood) = 2 drops of blood

Alex is exaggerating because he has only lost two drops of blood.

15. Genevieve must find the number of electron shells and the number of neutrons of an element. Should she consult the periodic table or a representation of the element according to the Rutherford-Bohr atomic model? Explain your answer.

Genevieve should consult the periodic table because the Rutherford-Bohr atomic model does not indicate the number of neutrons, she will be able to deduce it with the periodic table because it provides the relative atomic mass.

16. Catherine teaches art. She is organizing a sculpture project in which the students must choose between two alloys made of copper: bronze (80.098 g/mol, made of 70 percent copper) and brass (64.286 g/mol, made of 60 percent copper). Of her 30 students, 18 chose bronze and 12 chose brass. Each sculpture must weigh 750 g. How many moles of copper does Catherine need?

Quantity of copper in bronze:

750 g of bronze/sculpture × 18 sculptures = 13 500 g of bronze

$n = \frac{m}{M} = \frac{13500\ g\ of\ bronze}{80.098\ g/mol} = 168.54\ mol\ of\ bronze$

168.54 mol of bronze × 70% of copper = 117.98 mol of copper

Quantity of copper in brass:

750 g of brass/sculpture × 12 sculptures = 9000 g of brass

$n = \frac{m}{M} = \frac{9000\ g\ of\ brass}{64.286\ g/mol} = 140\ mol\ of\ brass$

140 mol of brass × 60% copper = 84 mol of copper

Total quantity of copper:

117.98 mol of copper + 84 mol of copper = 201.98 mol of copper

Catherine will need 201.98 moles of copper.