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GAMSAT*

Maths, Physics & General Chemistry

Comprehensive Preparation for GAMSAT Section 3: Physical Sciences

Book 2 from the 3-book GS GAMSAT Set

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EXAMPLE

The product of 7 and 2 is 14 since $7 \times 2 = 14$.

A **quotient** is the number obtained by dividing numbers.

EXAMPLE

In the equation $8 \div 2 = 4$, 4 is the quotient of 8 and 2.

Unlike a sum or a product, difference and quotient can result in different numbers depending on the order of the numbers in the expression:

$10 - 2 = 8$ while $2 - 10 = -8$
$20 \div 5 = 4$ while $5 \div 20 = 0.25$

The sum and difference of positive numbers are obtained by simple addition and subtraction, respectively. The same is true when adding negative numbers, except that the sum takes on the negative sign.

EXAMPLES

$(-3) + (-9) = -12$

$(-5) + (-12) + (-44) = -61$

On the other hand, when adding two integers with unlike signs, you need to ignore the signs first, and then subtract the smaller number from the larger number. Then follow the sign of the larger number in the result.

EXAMPLES

$(-6) + 5 = 6 - 5 = -1$

$7 + (-10) = 10 - 7 = -3$

When subtracting two numbers of unlike signs, start by changing the minus sign into its reciprocal, which is the plus sign. Next reverse the sign of the second number. This will make the signs of the two integers the same. Now follow the rules for adding integers with like signs.

EXAMPLES

$(-6) - 5 = (-6) + (-5) = -11$

$7 - (-10) = 7 + 10 = 17$

Multiplication and division of integers are governed by the same rules: If the numbers have like signs, the product or quotient is positive. If the numbers have unlike signs, the answer is negative.

EXAMPLES

$5 \times 6 = 30$

$-5 \times -3 = 15$

$81 \div 9 = 9$

$-20 \div -4 = 5$

$7 \times -4 = -28$

$-9 \times 6 = -54$

$-15 \div 3 = -5$

$16 \div -2 = -8$

The following are 2 typical GAMSAT-level dimensional analysis practice questions.

EXAMPLE 3

Consider the following diagram.

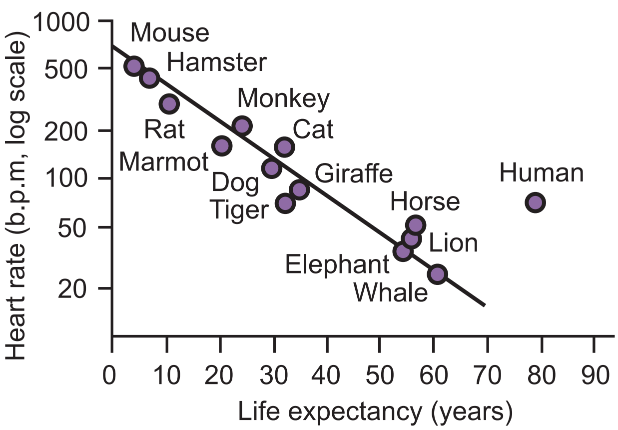


Figure 1: Heart rate in beats per minute (b.p.m.) on a log scale vs. life expectancy in years for various mammals.

Estimate the average number of heart beats over a lifetime for a person.

A. 2.9×10^{11}
B. 2.9×10^{9}
C. 2.9×10^{7}
D. 2.9×10^{5}

This question is asking for the number of heart beats per lifetime for a human being. If we can determine the rate of heart beats per minute from Figure 1, we could scale that quantity up to an hour, then a year, then a lifetime by estimating the average lifespan - also from Figure 1.

You can easily estimate your heart rate by counting your pulse while watching a clock for a minute for comparison, but this question refers to Figure 1.

The heart rate for 'Human' on the graph is approximately 60-70 b.p.m. (= beats per minute as explained by the caption below the graph). Because the answers are far enough apart, which commonly occurs during the real exam, whether you estimate 60 or 70 (or even 80), you will approximate the same answer. We will examine the log scale in GM 3.8 at which point you will better understand why the heart rate is most likely less than 75 b.p.m. From Figure 1, we can estimate life expectancy of a person as 80 years/lifetime.

Putting all of the preceding together, we get:

$$\frac{70 \text{ beats}}{1 \text{ minute}} \cdot \frac{60 \text{ minutes}}{1 \text{ hour}} \cdot \frac{24 \text{ hours}}{1 \text{ day}} \cdot \frac{365 \text{ days}}{1 \text{ year}} \cdot \frac{80 \text{ years}}{1 \text{ lifetime}}$$

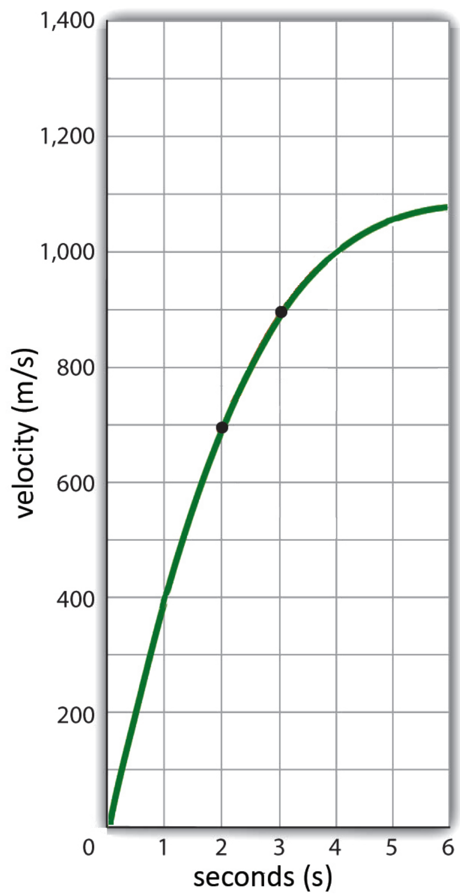
What happened to the units?

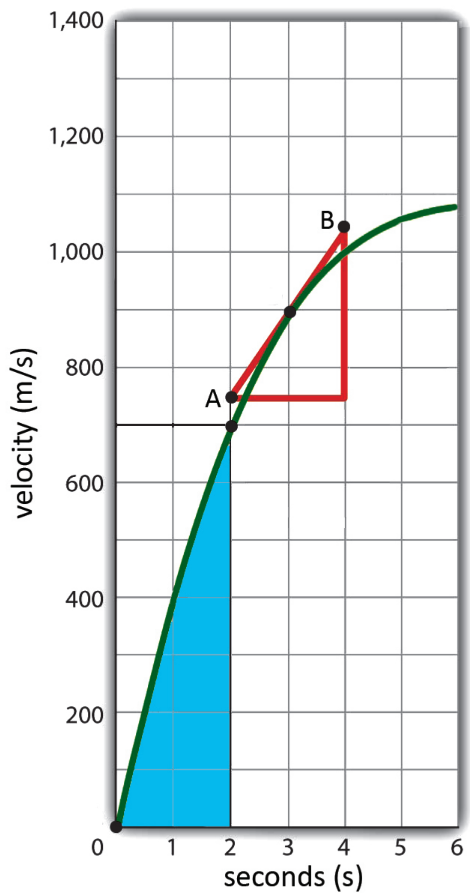
$$\frac{70 \text{ beats}}{1 \cancel{\text{minute}}} \cdot \frac{60 \cancel{\text{minutes}}}{1 \cancel{\text{hour}}} \cdot \frac{24 \cancel{\text{hours}}}{1 \cancel{\text{day}}} \cdot \frac{365 \cancel{\text{days}}}{1 \cancel{\text{year}}} \cdot \frac{80 \cancel{\text{years}}}{1 \text{ lifetime}}$$

As a result of the cancellations, the final units must be beats/lifetime, or in other words, heart beats over a lifetime.

We have completed the dimensional analysis, so what about the math?

Keeping in mind that the math needs to be done quickly and efficiently by hand,





Hints if required:

(1) **Hint:** try to calculate the slope of a straight line off the curve at 3 seconds. Why does the slope solve the problem? Take a look at the units. A slope is the change of y divided by the change of x. In terms of units, this would make m/s/s = m/s^2 = acceleration.

(2) **Hint:** determine the area of the curve below that segment of the graph (i.e. the first 2 seconds). One way to do so is to calculate the area of one box and then estimate how many boxes are below the curve. Why the area? Again, the units: the area of a square or rectangle is one side times the other side. For a graph, it is x times y. So here is what happens to the units: m/s x s = m = meters which is displacement.

3.6 Cartesian Coordinates in 3D

The GAMSAT will sometimes present 3D (3 dimensional) graphs to see if you are capable of a basic analysis.

EXAMPLE 1

Consider the following illustration of a 3D Cartesian coordinate system. Notice the origin *O* and the 3 axis lines *X*, *Y* and *Z*, oriented as shown by the arrows. The tick marks on the axes are one length unit apart. Look carefully at the black dot. What coordinate (x, y, z) would you give to identify the position of that dot? (2,2,3)? (3,2,4)? (4,3,2)? (2,4,3)? (2,3,4)? The black dot represents a point with coordinates x = 2, y = 3, and z = 4, or (2,3,4).

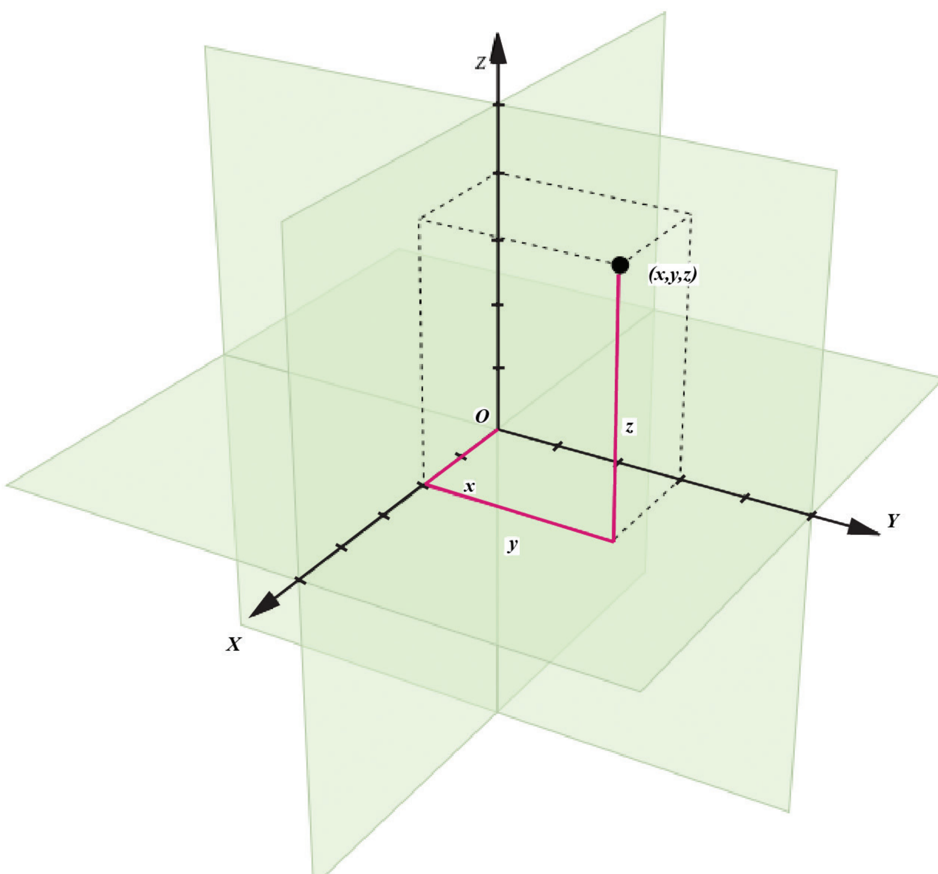


Figure IV.3.1: Three-dimensional Cartesian coordinate system. (Stolfi)

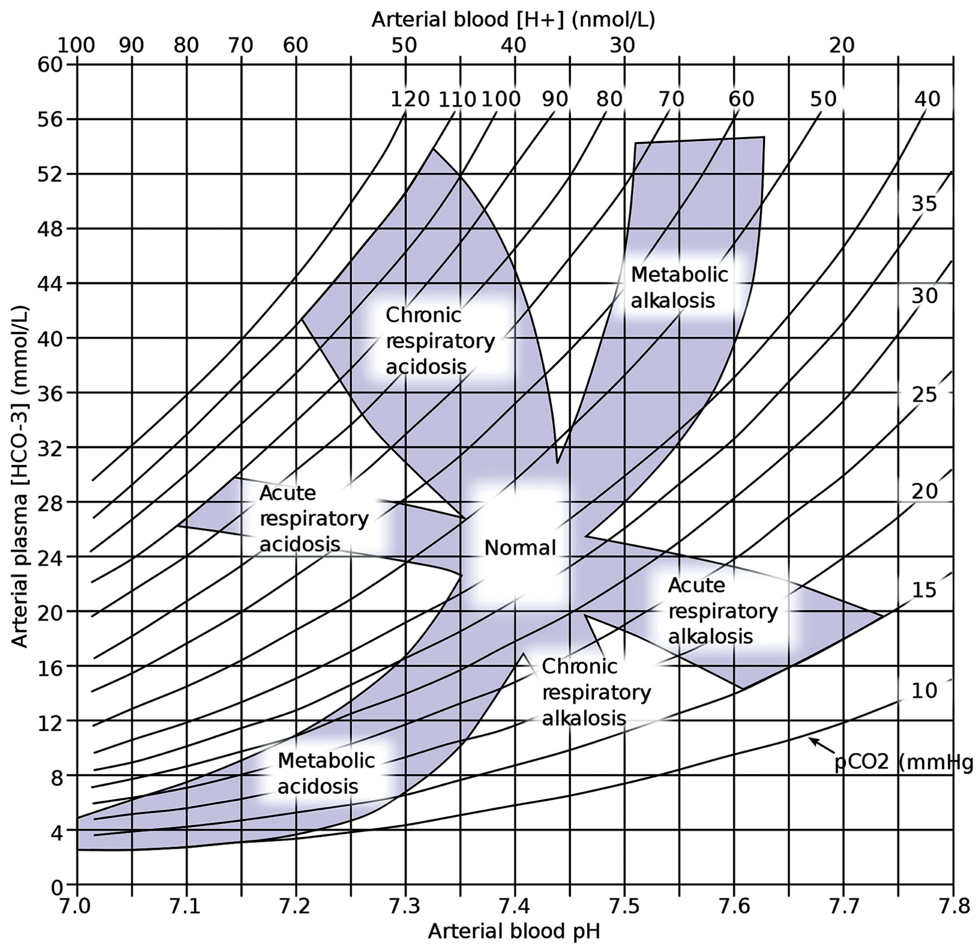


Figure IV.3.7 Human arterial blood acid-base balance and disorders

QUESTION 1

According to Figure IV.3.7, an arterial blood pH of 7.5 with a pCO_2 of 25, corresponds best with which of the following?

A. Metabolic alkalosis
B. Acute respiratory alkalosis
C. Chronic respiratory alkalosis
D. Chronic respiratory acidosis

QUESTION 2

Consider a patient with metabolic alkalosis. Based on Figure IV.3.7, which of the following would be most consistent with returning the patient back to normal?

A. Increase in arterial $[H^+]$, decrease arterial bicarbonate
B. Increase arterial pH, increase arterial bicarbonate
C. Decrease pCO_2, decrease arterial $[H^+]$
D. Increase pCO_2, decrease arterial bicarbonate

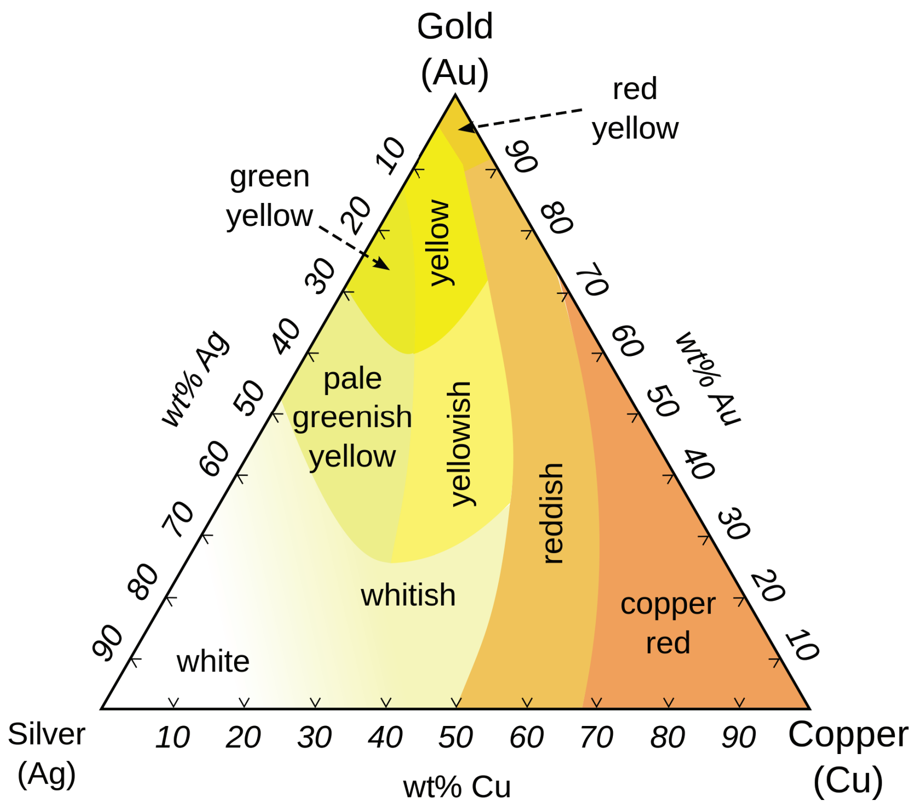


Figure IV.3.8 Trilinear diagram representing the percent by weight of 3 different metals and the resultant appearance of the mixture (= *metal alloy*). en.wikipedia.org/wiki/Colored_gold Ref: Metallos

QUESTION 1

Based on the information provided, choose the correct statement.

A. Pure gold is 'yellow' gold.
B. Increasing copper in the alloy increases the chance of a possible greenish appearance.
C. "Yellowish" gold is present when ½ of the mixture is gold, while silver and copper are equal.
D. Pure silver added to 'pale greenish yellow' gold can produce 'yellow' gold.

QUESTION 2

Equal amounts by weight of 14K and 9K gold are mixed together. According to Figure IV.3.8, which of the following is the likely result of the appearance of the mixture if it contains 10% copper?

A. Pale greenish yellow
B. Yellow
C Yellowish
D. Whitish

TRANSLATIONAL MOTION
Chapter 1

Memorize

* Trigonometric functions: definitions
* Pythagorean theorem
* Define: displacement, velocity, acceleration
* Equations: acceleration, kinematics

Understand

* Scalar vs. vector
* Add, subtract, resolve vectors
* Determine common values of functions
* Conversion of the angle to other units
* Displacement, velocity, acceleration (avg. and instant.) including graphs

Not Required*

* Knowledge beyond introductory-level (A-level/Leaving Certificate/Year 12) course
* Any derivatives with or without vectors
* Complex vector systems

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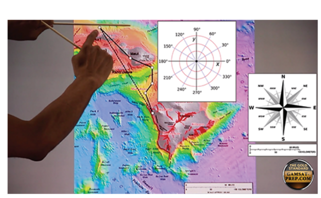
Introduction

Translational motion is the movement of an object (or particle) through space without turning (rotation). Displacement, velocity and acceleration are key vectors — specified by magnitude and direction — often used to describe translational motion. Being able to manipulate and resolve vectors is critical for problem solving in GAMSAT Physics.

Whether science or non-science background: (1) please complete the GAMSAT Math chapters prior to starting Physics; (2) closely consider information underlined, in italics, in red boxes or highlighted in yellow; (3) go to your online access account and consider: watching videos, printing our GAMSAT Physics Equation List or making your own, and irrespective of your initial comfort level, try some online practice questions because they will begin with the basics and then work up to challenge you.

Additional Resources

Free Online Q&A + Forum



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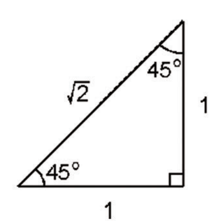
Flashcards

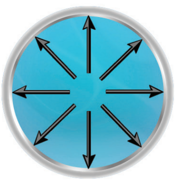


Special Guest

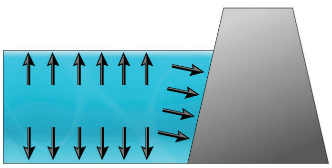
* The real GAMSAT may have advanced level information presented (ie. in a passage) but previous knowledge of said information is not required to answer the questions that would follow. Practice ACER and GS practice GAMSATs can help you clarify this point.

We will now examine 6 key rules of incompressible fluids (liquids) that are not moving (*statics*).

1) In a fluid confined by solid boundaries, pressure acts perpendicular to the boundary – it is a normal force, sometimes called a *surface force*.



pipe or tube



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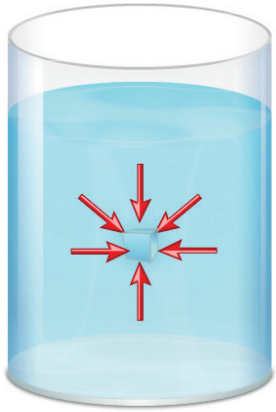
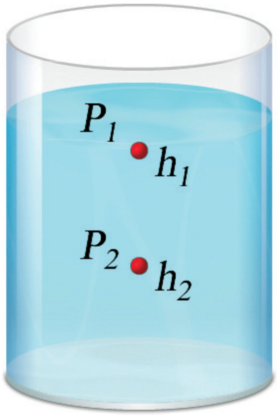
2) At any particular depth, the pressure of the fluid is the same in all directions.



3) The fluid or *hydrostatic pressure* depends on the density and the depth of the fluid. So it is easy to calculate the change in pressure in an open container, swimming pool, the ocean, etc.:

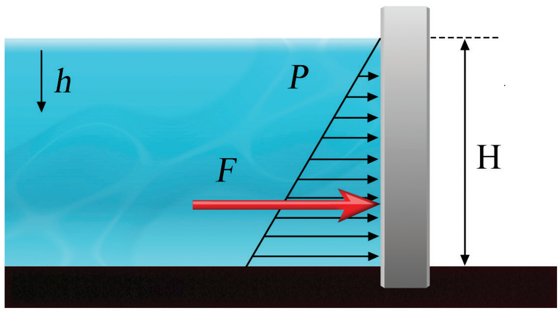


P_1 = atmospheric pressure
h_1 = surface = a depth of 0
$P_2 - P_1 = \Delta P$
$h_2 - h_1 = \Delta h$

$\Delta P = \rho g \Delta h$

Vertical plane surfaces

We can now combine rules 1, 2 and 3 about fluids to examine a special case which is that of a vertical plane surface like a vertical wall that is underwater.



Of course pressure varies linearly with depth because $\Delta P = \rho g \Delta h$.

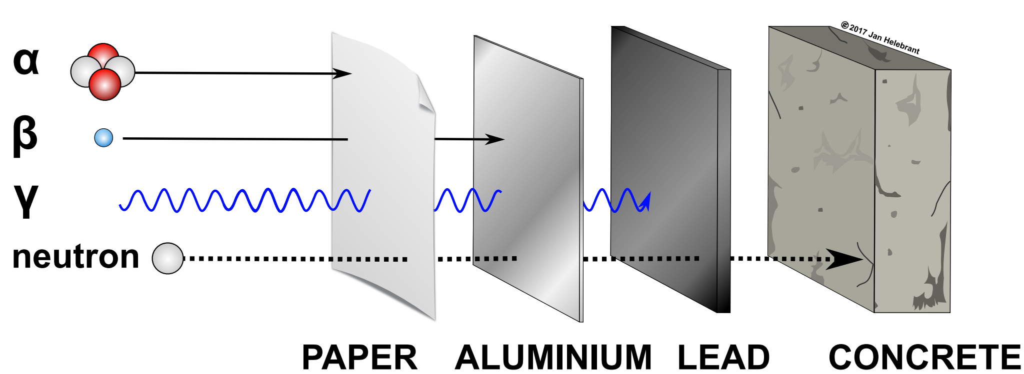
mutation) in which the parent and daughter nuclei are of different elements. For example, a C-14 atom may undergo a beta decay and emit radiation and as a result, transform into a N-14 daughter nucleus. It is also possible that radioactive decay does not result in transmutation but only decreases the energy of the parent nucleus. As an example, a Ni-28 atom undergoing a gamma decay will emit radiation and then transform to a lower energy Ni-28 nucleus. The following is a brief description of the three principle types of radioactive decay.

(1) Alpha (α) decay: Alpha decay is a type of radioactive decay in which an atomic nucleus emits an alpha particle. An alpha particle is composed of two protons and two neutrons which is identical to a helium-4 nucleus. An alpha particle is the most massive of all radioactive particles. Because of its relatively large mass, alpha particles tend to have the most potential to interact with other atoms and/or molecules and ionize them as well as lose energy. As such, these particles have the lowest penetrating power (= *least ability to go straight through matter*, an object). If an atomic nucleus of an element undergoes alpha decay, this leads to a transmutation of that element into another element as shown below for the transmutation of Uranium-238 to Thorium-234:

$$^{238}{}_{92}U \rightarrow {}^{234}{}_{90}Th + {}^{4}{}_{2}He^{2+}$$
$$^{238}U \rightarrow {}^{234}Th + \alpha$$

(2) Beta (β) decay: Beta decay is a type of decay in which an unstable nucleus emits an electron or a positron. A positron is the antiparticle of an electron and has the same mass as an electron but opposite in charge. The electron from a beta decay forms when a neutron of an unstable nucleus changes into a proton and in the process, an electron is then emitted. The electron in this case is referred to as a beta minus particle or β^-. In beta decays producing positron emissions, it is referred to as beta plus or β^+. For an

Penetrating power of different types of radiation



rate equation can thus be expressed as follows: rate = $k[A]^2$.

Hence, the rate orders or exponents in the rate law equation can be integers, fractions, or zeros and are not necessarily equal to the stoichiometric coefficients in the given reaction except when a reaction is the rate-determining step (or elementary step). Consequently, although there are other orders, including both higher and mixed orders or fractions that are possible as described, the three described orders (0, 1st and 2nd), are amongst the most common orders studied.

As shown by the graphical representation below, for the zero order reactant, as the concentration of reactant A decreases over time, the slope of the line is constant and thus the rate is constant. Moreover, the rate does not change regardless of the decrease in reactant A concentration over time and thus the zero order rate order. For the first order, the decrease in reactant A concentration is shown to affect the rate of reaction in direct proportion. Thus, as the concentration decreases, the rate decreases proportionally. Lastly, for the second order, the rate of the reaction is shown to decrease proportionally to the square of the reactant A concentration. In fact, the curves for 1st and 2nd order reactions resemble exponential decay.

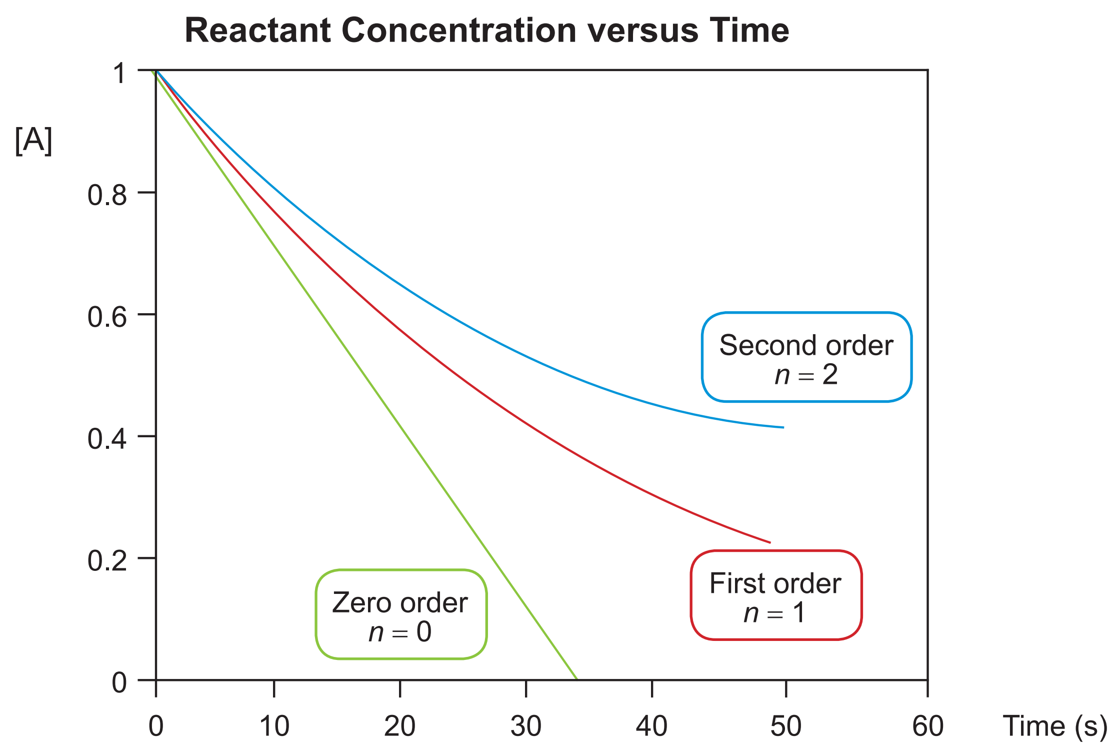


Figure III.A.9.0: Reactant concentration vs. time curves. Notice that first and second order reactions have exponential decay curves (PHY 10.5) but, of course, second order reactions decay faster. It is expected that you can recognize the graphs above and those in the next section (CHM 9.2.1).

catalysts. They are protein molecules with very large molar masses containing one or more active sites (BIO 4.1-4.4). Enzymes are very specialized catalysts. They are generally specific and operate only on certain biological reactants called substrates. They also generally increase the rate of reactions by large factors. The general mechanism of operation of enzymes is as follows:

Enzyme (E) + Substrate (S) $\rightarrow$ ES (complex)

ES $\rightarrow$ Product (P) + Enzyme (E)

If we were to compare the energy profile of a reaction performed in the absence of an enzyme to that of the same reaction performed with the addition of an enzyme we would obtain Figure III.A.9.2.

As you can see from Figure III.A.9.2, the reaction from the substrate to the product is facilitated by the presence of the enzyme because the reaction proceeds in two fast steps (low E_a's). Generally, catalysts (or enzymes) stabilize the transition state of a reaction by lowering the energy barrier between reactants and the transition state. Catalysts (or enzymes) do not change the energy difference between reactants and products. Therefore, catalysts do not alter the extent of a reaction or the chemical equilibrium itself. Generally, the rate of an enzyme-catalysed reaction is:

$$\text{rate} = k[ES]$$

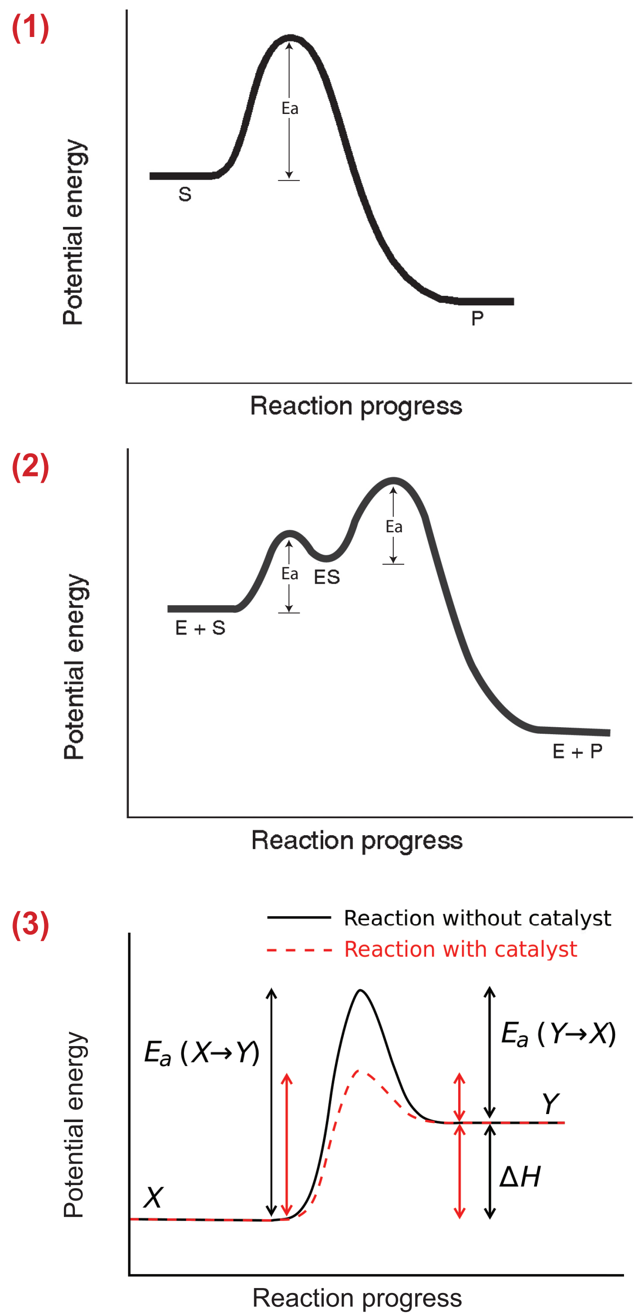


Figure III.A.9.2: Potential energy diagrams: **(1)** exothermic (CHM 9.5) without a catalyst; **(2)** exothermic with a catalyst; **(3)** showing both with and without a catalyst - the forward reaction being endothermic, thus the reverse reaction is exothermic.