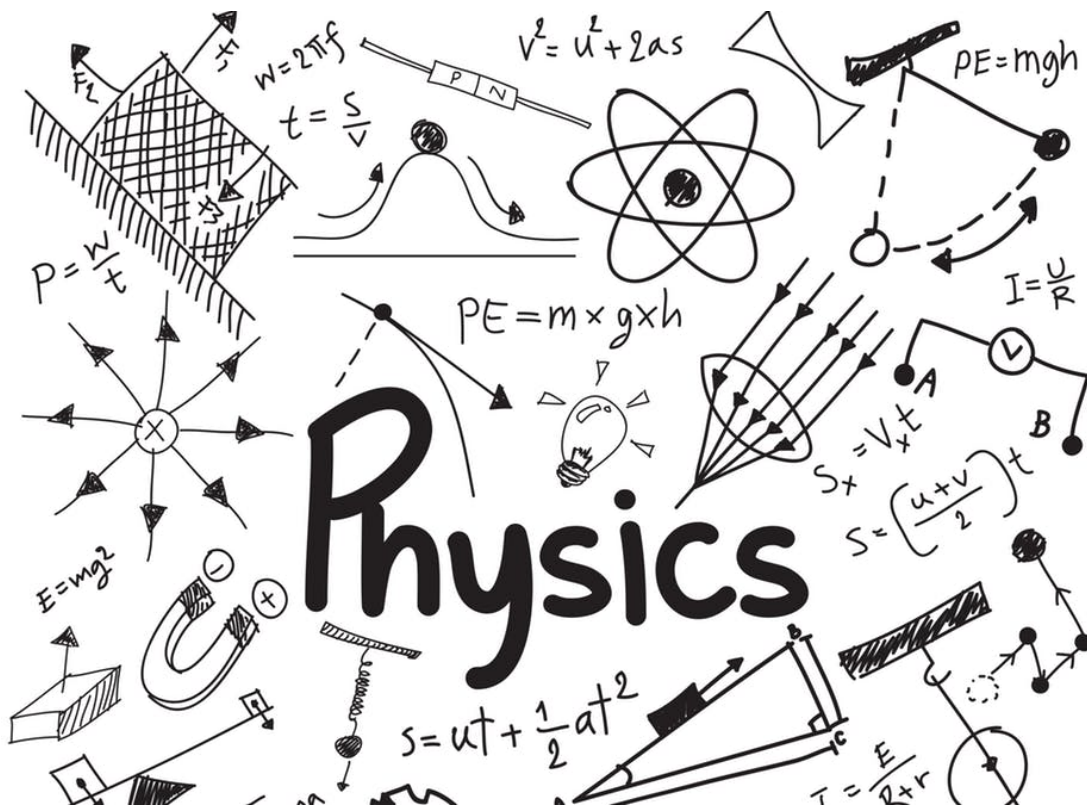


# SCIENCE 10

## FINAL EXAM REVIEW BOOK 3



*ENERGY IS CONSERVED, AND ITS TRANSFORMATION CAN AFFECT LIVING THINGS AND THE ENVIRONMENT.*

NAME: \_\_\_\_\_

BLOCK: \_\_\_\_\_

# Study Checklist

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This review booklet is by no means a "practice final". It is a collection of practice questions on each unit, meant to guide your final exam studying and prepare you for the types of questions you are likely to see. DO NOT treat this booklet as a practice test. If you're stuck on a question, look it up and ask for help! DO NOT go straight to the answer key when you come across a question you cannot remember how to do. Difficult questions SHOULD guide your study! Always look up a concept in your class notes if you are stuck, then attempt the question again.

## BEFORE beginning this booklet you should:

- read through your class notes booklet on *each topic*
- make your own "quick summary page" of important formulas & key concepts for the unit
- review quizzes & tests from the unit to recall strengths & weaknesses (*a great study method would be to re-do old quizzes & tests on a separate piece of paper*)

## WHILE working through this booklet you should:

- look up concepts & example problems in your class notes when you come across a problem you are stuck on
- make a list of "questions to ask my teacher" so you can come to class and use your time efficiently.

## Questions I'm having difficulty with:

Page	Question Number #	Topic

# Unit 3: Physics - Energy & Transformations

*use this page to make your own KEY summary notes*

### Kinetic Energy Practice Questions:

1. A cheetah can run briefly with a speed of 31.0 m/s. Suppose a cheetah with a mass of 47.0 kg runs at this speed. What is the cheetah's kinetic energy?
2. A ping pong ball has a mass of about 2.45 grams. Suppose that Forrest Gump hits the ball across the table with a speed of about 4.00 m/s. What is the ball's  $E_k$ ?
3. The largest land predator is the male polar bear, which has a mass of around 500.0 kg. If the top speed of a male polar bear is 11.0 m/s, how much  $E_k$  does it have?
4. Though slow on land, the leatherback turtle holds the record for the fastest water speed of any reptile. The largest leatherback yet discovered could swim at a speed of 9.78 m/s. If its  $E_k$  was 60,800 J, what was its mass?
5. What is the  $E_k$  of a 1.00 kg hammer swinging at 20.0 m/s?



### Potential Energy Practice Questions:

1. A goat jumps up in the air and reaches a height of 39.0 m above the surface of the Earth. How much potential energy will the 31.0 kg goat have at this height?
2. If a rock has 250 MJ of potential energy while sitting on the edge of a cliff 42.0 m above the valley floor, what is its mass?
3. The International Space Station is 405 km above the Earth's surface and has a mass of 419 000 kg. If the gravitational field strength is only 8.72 N/kg at this altitude, how much potential energy does the ISS have?
4. If you had a job lifting books from the floor up onto a bookshelf ( $h = 1.70$  m), and the average book had a mass of 1.20 kg, and you had 1000 books to put away, how much extra potential energy would all those books have when you were done? Where did this energy come from?

5. If 9.75 kJ of  $E_p$  was given to a lemon while lifting it, and the lemon had a mass of 218 g, how high was it lifted?
  
  
  
  
  
  
  
  
  
  
6. How high could a 60.0 kg pole vaulter get above the ground if she could convert 2975 J of energy into  $E_p$  ?
  
  
  
  
  
  
  
  
  
  
7. What is the mass of one chocolate chip if throwing it 2.10 m vertically into the air requires 68.5 mJ of energy? (ignoring energy lost to friction)
  
  
  
  
  
  
  
  
  
  
8. An astronaut jumping on the moon could get his 140 kg of mass (body plus space suit) to a height of 1.73 m above the surface (measured to his center of mass). At this point, his  $E_p$  was only 412 J. What must the gravitational field strength be on the moon?
  
  
  
  
  
  
  
  
  
  
9. If the mass of an object were to suddenly double, what would happen to its  $E_p$  ?
  
  
  
  
  
  
  
  
  
  
10. If the height of an object were to suddenly double, what would happen to its  $E_p$  ?

## CONSERVATION OF ENERGY PROBLEMS

The **law of conservation of energy** is a law of science that states that energy cannot be created or destroyed, but only changed from one form into another or transferred from one object to another.

This means that the total energy in a *closed system* must remain constant, or the total energy ( $E_t$ ) at any time, must equal the total energy at any other point in time ( $E_t'$ ).

$$E_t = E_t'$$



An automobile engine changes chemical energy to mechanical and heat energy.



A tree changes radiant energy to chemical energy.



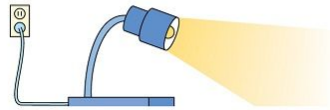
Hammering a nail changes mechanical energy to deformation and heat energy.



A thermonuclear reaction changes nuclear energy to radiant and heat energy.



An electric mixer changes electrical energy to mechanical and heat energy.



A lamp changes electrical energy to radiant and heat energy.

**Note** that in a nuclear reaction, mass may be lost and converted to energy according to Einstein's formula  $E = mc^2$  where  $E$  is energy in joules,  $m$  is the mass in kilograms, and  $c$  is the speed of light in m/s.

### Example Problem:

A ball is thrown upward and reaches a height of 21.0 m above the point of release. What was the velocity of the ball just after being released?

Known Values:

$m = ?$  (sometimes this is not needed, stay tuned...)

$h = 21.0$  m

$g = 9.80$  N/kg (on Earth)



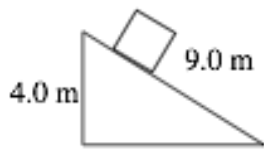
Formula:	$E_t = E_t'$	(total energy before = total energy after)
	$E_k = E_p'$	(only kinetic E at bottom, only potential E at the top)
	$\frac{1}{2}mv^2 = mgh$	(notice there is an "m" on either side, so divide both sides by m! Neat eh?)
	$\frac{1}{2}v^2 = gh$	(now multiply both sides by 2)
	$v^2 = 2gh$	(now take the square root of both sides)
	$v = \sqrt{2gh}$	
	$v = \sqrt{2(9.80)(21.0)}$	(substitute in the data values)
	$v = 20.2879$	(calculate)
	$v = 20.3 \text{ m/s}$	(round off and add the units)

**Practice Questions:** (Your solutions should be organized similar to the example problem. Show all your steps please. Round to 3 digits)

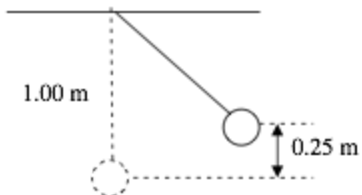
1. A student is dropped. If they reach the floor at a speed of 3.20 m/s, from what height did they fall? (no students were harmed in the making of this problem.)
  
2. A heavy object is dropped from a vertical height of 8.00 m. What is its speed when it hits the ground?
  
3. A bowling ball is dropped from the top of a building. If it hits the ground with a speed of 37.0 m/s, how tall was the building?

4. A safe is hurled down from the top of a 135 m tall building at a speed of 11.0 m/s. What is its velocity as it hits the ground?

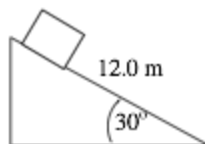
5. A box slides down a frictionless ramp. If it starts at rest, what is its speed at the bottom? (assume the box started at the very top of the ramp)



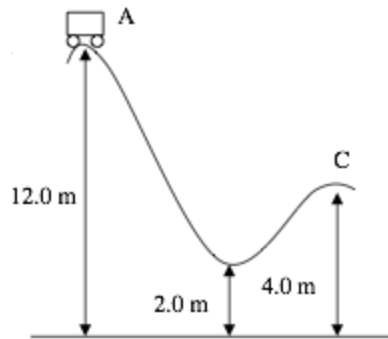
6. A pendulum is dropped from the position shown, 0.250 m above its equilibrium position. What is the speed of the pendulum bob as it passes through its equilibrium position?



7. A box slides down a frictionless incline as shown. If the box starts from rest, what is its speed at the bottom? (assume the box started at the very top of the ramp)

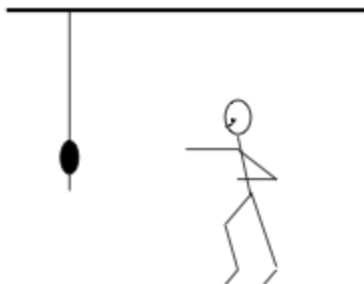


8. A roller coaster car starts from rest at point A. What is its speed at point C if the track is frictionless?



9. The roller coaster shown above has a mass of 525 kg and is travelling at 2.10 m/s at point A, and is later travelling at 12.7 m/s at the lowest point. How much energy was lost to heat on the trip down?

10. An 80.0 kg student running at 3.50 m/s grabs a rope that is hanging vertically. How high will the student swing?



## THERMAL ENERGY PROBLEMS

**Thermal energy ( $E_h$ )** is an example of kinetic energy, as it is due to the motion of particles, with motion being the key. Thermal energy results in an object or a system having a temperature that can be measured. Thermal energy can be transferred from one object or system to another in the form of **heat**. Sometimes thermal energy is defined as the total internal energy of all the particles in a body. This would include the translational (sideways) kinetic energy that could be detected by a thermometer, as well as all the energies contained in the vibrations and rotations of particles that cannot be detected. This is why a mass can absorb energy and not increase its temperature (for example: when melting ice into liquid water, it will take in energy, but not change temperature until the liquid has formed, then the temperature will start to rise.)

To calculate the **total thermal energy,  $E_h$** , of an object, use the following formula:

$$E_h = mCT$$

Where:

Mass ( $m$ ) is measured in kilograms (kg)

Specific heat capacity ( $C$ ) is measured in joules per kilogram per kelvin (J/kg·K)

Temperature ( $T$ ) measured in kelvin (K)

$E_h$  is measured in joules (J) [note, we use the subscript "h" (from "heat") for thermal energy because "t" will be used later for "total" energy. It's not quite right, but will do for now.]

It is rare to need to calculate the total thermal energy of an object. Most often we are interested in the increase or decrease of thermal energy. Heat is defined as the change in thermal energy ( $\Delta E_h$ ). Heating refers to an increase in thermal energy and cooling refers to a decrease in thermal energy.

To calculate the **change in thermal energy** (or heat)  $\Delta E_h$  of an object, use the following formula:

$$\Delta E_h = mC\Delta T$$

The size of one kelvin and the size of one degree Celsius is the same on a thermometer, therefore the change in temperature ( $\Delta T$ ) can be measured in either kelvin or degrees Celsius and is defined as the difference between the final temperature  $T_f$  and the initial temperature  $T_i$

$$\Delta T = T_f - T_i$$

The specific heat capacity can then be in (J/kg·K) or in (J/kg·°C).

**Note:** To earn full marks when solving science word problems, you must **Show your work**. Please refer to the problem solving steps given in class. Don't forget to convert units into the proper base units before calculating.

### Example Problems:

1. How much energy would be required to raise the temperature of The One Ring from 31.0°C to 1 064°C (the melting point of gold) when Gollum releases it into the lava of Mt. Doom? Let's assume the ring has a mass of 5.00 g.

#### Solution:

For all these problems we will need the specific heat capacity of each substance.

Sometimes it will be given to you, but if not, look it up. C for gold is 129 J/kg°C

$$m = 5.00 \text{ g} = 0.00500 \text{ kg}$$

$$C = 129 \text{ J/kg}^\circ\text{C}$$

$$T_i = 31.0^\circ\text{C}$$

$$T_f = 1\ 064^\circ\text{C}$$

$$\begin{aligned}\Delta E_h &= mC\Delta T \\ &= (0.00500)(129)(1\ 064 - 31.0) \\ &= 666.285 \\ &= 666 \text{ J}\end{aligned}$$

**Practice Questions:** (Your solutions should be organized similar to the example problem. Show all your steps please)

Use the specific heat capacity table here: [goo.gl/65gAMu](http://goo.gl/65gAMu)

1. How much heat energy is required to warm 3.5 kg of water from 16°C to 96°C?

2. What is the mass of a lead block if it takes 67 kJ to raise the temperature by  $100.0^{\circ}\text{C}$
  
3. If a pile of snow with a mass of 525 kg loses 7.40 MJ of thermal energy during the night, how much will the temperature of the snow drop?
  
4. What is the final temperature of 0.63 kg of water that releases 2290 joules of thermal energy? The water had an initial temperature of  $48.2^{\circ}\text{C}$ .
  
5. What is the **total** thermal energy in a human body? Let's assume some things: The average specific heat capacity of a human body is approximately  $3500 \text{ J}/(\text{kg}\cdot\text{K})$  at normal conditions. The average human has a mass of 72.0 kg. Body temperature is normally  $37.0^{\circ}\text{C}$ .
  
6. In his part time job as a blacksmith, Nathan was quenching (cooling) a 350 g iron horseshoe from  $470.0^{\circ}\text{C}$  to  $30.0^{\circ}\text{C}$  by plunging the horseshoe into a bucket of cold water. How much thermal energy was lost by the horseshoe?

7. If the bucket of water that Nathan (from the last question) contained 14.0 kg of water that had an initial temperature of 25.0 °C, how much would the water temperature increase when cooling the horseshoe?
  
  
  
  
  
  
  
  
  
  
8. A standard gold bar, also referred to as gold ingot or gold bullion has a mass of 12.4 kg (what is known as 400 troy ounces). If the melting point of gold is 1063 °C, how much energy would be needed to bring one standard gold bar from room temperature of 20.0 °C to its melting point?
  
  
  
  
  
  
  
  
  
  
9. If two bars of copper and gold have equal masses of 250 g, and have equal starting temperatures, how much will their final temperatures differ by if 6.5 kJ of thermal energy is added to each of the bars?
  
  
  
  
  
  
  
  
  
  
10. Milan started a fire in her fireplace which has a granite surround with a mass of 240 kg. If the granite started at 18.0 °C, how much energy was needed to raise its temperature to 32.0 °C?

# Unit 3: Physics - Nuclear Reactions

*use this page to make your own KEY summary notes*



# Isotopes and Ions

## What to Do

Answer each question in the space provided.

1. Complete the following table by filling in the missing information about ions.

Name of Ion	Symbol	Number of Protons	Number of Electrons	Ion Charge
lithium ion				
		19	18	1+
	$\text{Mg}^{2+}$			
chloride ion				
		9		1-
	$\text{O}^{2-}$			
	$\text{I}^-$			
scandium ion				
			18	2-
	$\text{Se}^{2-}$			
		7	10	
	$\text{Al}^{3+}$			
			10	4-
calcium ion				
phosphide				

2. Complete the following table by filling in the missing information about isotopes. The first row is completed as an example.

Name of Isotope	Symbol	Mass Number	Number of Protons	Number of Neutrons
hydrogen-3	${}^3_1\text{H}$	3	1	2
scandium-49				
	${}^{60}_{27}\text{Co}$			
nitrogen-15				
	${}^{238}_{92}\text{U}$			
	${}^{129}_{53}\text{I}$			
			56	79
		86		48
	${}^{18}_8\text{O}$			
carbon-14				

3. Although oxygen-16 is the most common isotope of oxygen, oxygen-17 and oxygen-18 are also present. Despite the differences in the atomic structures of the three isotopes, there is no difference in how they form ionic or covalent compounds with atoms of other elements. Explain how this can be.

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# Isotopes

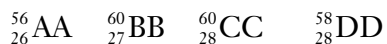
**Goal** • Use this page to show your understanding of isotopes.

Circle the letter of the best answer.

1. What do two isotopes of an element have?
  - A. the same number of electrons but a different number of protons
  - B. the same number of neutrons but a different number of protons
  - C. the same number of protons, electrons, and neutrons
  - D. the same number of protons but a different number of neutrons
2. What does a sodium-23 isotope contain?
  - A. 11 protons and 12 neutrons
  - B. 11 protons and 23 neutrons
  - C. 12 protons and 11 neutrons
  - D. 23 protons and 23 neutrons
3. Isotopes are two atoms of the same element that do which of the following?
  - A. become electrically charged
  - B. differ in mass but are chemically alike
  - C. give away electrons to become positively charged
  - D. have the same mass but different chemical properties
4. Which of the following describes the isotope  ${}^{40}_{20}\text{Ca}$  ?
  - A. 40 protons and 20 neutrons
  - B. 20 protons and 40 neutrons
  - C. 20 protons and 20 neutrons
  - D. 40 electrons and 20 neutrons

**Use the following information to answer the next two questions.**

The nuclear notations for four mystery elements are shown below.



5. How many subatomic particles does mystery element AA have?
  - A. 26 protons, 26 neutrons, and 26 electrons
  - B. 26 protons, 30 neutrons, and 26 electrons
  - C. 30 protons, 26 neutrons, and 30 electrons
  - D. 26 protons, 56 neutrons, and 30 electrons
6. Which mystery elements are isotopes of the same element?
  - A. AA and BB
  - B. BB and CC
  - C. CC and DD
  - D. AA and DD

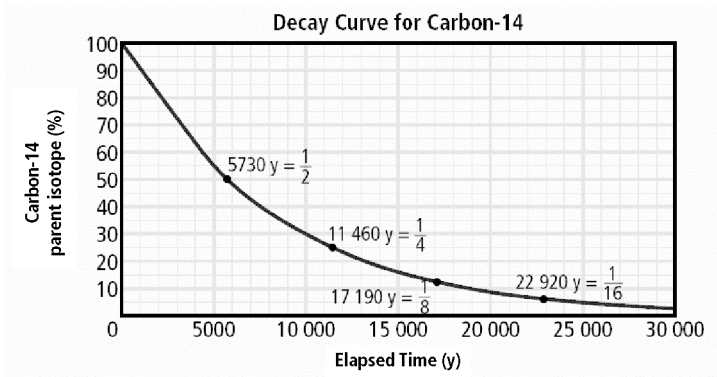
# Half-Life and Radioisotope Dating

**Goal** • Demonstrate your understanding of the use of half-life in radioisotope dating.

## What to Do

Answer the questions in the space provided.

1. Examine the graph showing the decay curve for carbon-14. The graph shows the amount of radioactive carbon-14 that would be in a sample of organic material for 30 000 years after the organism died.



- (a) Define half-life.

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- (b) How long is one half-life for carbon-14? \_\_\_\_\_

- (c) What percentage of carbon-14 remains (i) after one half-life? \_\_\_\_\_  
(ii) after two half-lives? \_\_\_\_\_ (iii) after three half-lives? \_\_\_\_\_

- (d) Use the graph to estimate the percentage of carbon-14 remaining after  
(i) 5000 years \_\_\_\_\_ (ii) 10 000 years \_\_\_\_\_ (iii) 15 000 years \_\_\_\_\_.

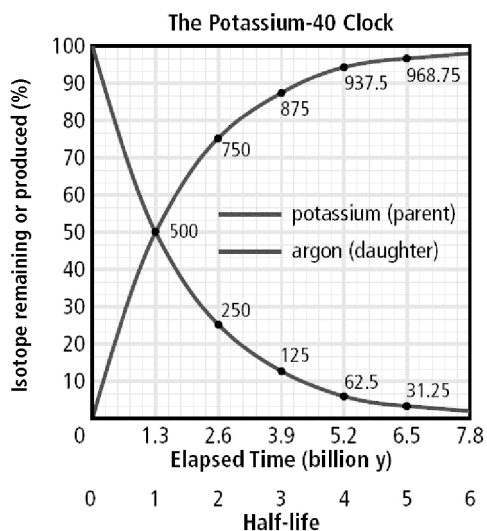
- (e) Use the graph to estimate the number of years that have passed since the organism died if the percentage of parent isotope that remains is  
(i) 40% \_\_\_\_\_ (ii) 20% \_\_\_\_\_ (iii) 5% \_\_\_\_\_.

- (f) Explain why carbon-14 half-life measurements are not effective in dating an organism that has been dead for more than 50 000 years.

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2. Volcanic rocks can be dated using the potassium-40 clock, a dating method based on the decay of the potassium-40 isotope into the argon-40 isotope. Potassium-40 can exist as hot molten rock, whereas argon-40, the daughter isotope, escapes from the molten rock because it is a gas. When the molten rock solidifies, potassium-40 is present, but argon-40 is absent. The age of volcanic rock can be measured by comparing the amount of these two isotopes present in the rock.



- (a) Why is there no argon-40 present in the molten rock when it solidifies?

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- (b) After many years, argon-40 is present in volcanic rock containing potassium-40, even though no argon-40 was there to begin with. How did the argon-40 get there?

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- (c) What is the length, in years, of one half-life of potassium-40? \_\_\_\_\_

- (d) Suppose a sample of volcanic rock contained 100 nanograms (a nanogram is a billionth of a gram) of potassium-40 when the rock first formed. How many nanograms of potassium-40 and of argon-40 would be present in the sample after

- (i) 1 half-life? \_\_\_\_\_  
 (ii) 2 half-lives? \_\_\_\_\_  
 (iii) 3 half-lives? \_\_\_\_\_

3. The table of parent-daughter isotopes shows three different isotope pairs that are used in radioisotope dating. Examine the chart and answer the following questions.

Isotope		Half-Life of Parent (y)	Effective Dating Range (y)
Parent	Daughter		
uranium-235	lead-207	710 million	> 10 million
potassium-40	argon-40	1.3 billion	10 000 to 3 billion
carbon-14	nitrogen-14	5730	up to 50 000

- (a) Lead-207 is called the daughter of uranium-235. What does this mean?

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- (b) How old is a rock sample that contains uranium-235 and lead-207 in equal amounts?

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- (c) The age of Earth was first established in 1953 when Claire C. Patterson of the California Institute of Technology used a uranium-lead clock to analyze rock. In comparing amounts of uranium-235 with lead-207, he established that slightly less than 8 half-lives of uranium-207 had passed since the rock formed. Using this data, estimate the age of Earth.

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- (d) The rocks that make up the Canadian shield are extremely old. They are estimated to be between 3.7 and 3.8 billion years. (A billion is a thousand million).

(i) Estimate how many half-lives of uranium-235 would have passed in a sample of rock this old. \_\_\_\_\_

(ii) Estimate the percentage of original uranium that would remain in a sample of rock from the Canadian shield. \_\_\_\_\_

- (e) Suppose a sample of rock from the Canadian shield were analyzed using the potassium-40 clock. What information could this give about the age of rock?

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- (f) Could carbon-14 dating be used to estimate the age of rocks in the Canadian shield? Explain.

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# Practice Quiz

**Goal** • Check your understanding of Isotopes & Nuclear Reactions

## What to Do

Circle the letter of the best answer. You may refer to a periodic table, an ion chart, and a common isotope pairs chart.

1. Which of the following is true of subatomic particles in a nucleus of vanadium-50?

- A. It has 23 protons and 27 neutrons.
- B. It has 23 protons and 28 neutrons.
- C. It has 27 protons and 23 neutrons.
- D. It has 27 protons and 51 neutrons.

23	5+
<b>V</b>	4+
Vanadium	
50.9	

2. Which of the following nuclear decay equations represent alpha decay?

I	${}_{80}^{201}\text{Hg} \rightarrow {}_{81}^{201}\text{Tl} + {}_{-1}^0\beta$
II	${}_{91}^{231}\text{Pa} \rightarrow {}_{89}^{227}\text{Ac} + {}_2^4\text{He}$
III	${}_{89}^{225}\text{Ac} \rightarrow {}_{87}^{221}\text{Fr} + {}_2^4\alpha$
IV	${}_{28}^{60}\text{Ni}^* \rightarrow {}_{28}^{60}\text{Ni} + {}_0^0\gamma$

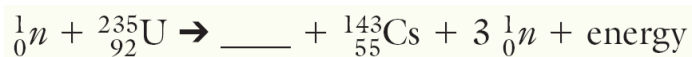
- A. I and IV only
  - B. II and III only
  - C. III and IV only
  - D. I and III only
3. Consider the following partly completed nuclear decay equation.



What is the symbol that correctly completes this equation?

- A.  ${}^6_{14}\text{C}$
- B.  ${}^4_{10}\text{Be}$
- C.  ${}^5_{14}\text{B}$
- D.  ${}^7_{14}\text{N}$

4. Refer to the Common Isotope Pairs Chart to determine the maximum effective dating range for carbon-14 dating.
- 14 years
  - 5730 years
  - 14 600 years
  - 50 000 years
5. Refer to the Common Isotope Pairs Chart to determine the age of a sample of rock that contains equal amounts of uranium-235 and lead-207.
- 355 million years
  - 710 million years
  - 2.25 billion years
  - 4.5 billion years
6. Potassium-40 is a radioactive isotope with a half-life of 1.3 billion years. It has the daughter isotope argon-40. How old is a rock that is found to contain 1.0 g of potassium-40 and 3.0 g of argon-40?
- 0.65 billion years old
  - 1.3 billion years old
  - 2.6 billion years old
  - 3.9 billion years old
7. Which nuclear symbol correctly completes the following nuclear reaction?



- ${}_2^4\text{He}$
  - ${}_{37}^{92}\text{Sr}$
  - ${}_{37}^{90}\text{Sr}$
  - ${}_{55}^{143}\text{Cs}$
8. Which equation best represents the type of process that occurs in a CANDU reactor?
- $\text{C}_7\text{H}_{16} + 11\text{O}_2 \rightarrow 7\text{CO}_2 + 8\text{H}_2\text{O} + \text{energy}$
  - ${}_0^1n + {}_{92}^{235}\text{U} \rightarrow {}_{36}^{92}\text{Kr} + {}_{56}^{121}\text{Ba} + 3 {}_0^1n + \text{energy}$
  - ${}_{99}^{226}\text{Ra} \rightarrow {}_{86}^{222}\text{Rn} + {}_2^4\text{He} + \text{energy}$
  - ${}_1^2\text{H} + {}_1^3\text{H} \rightarrow {}_2^4\text{He} + {}_0^1n + \text{energy}$



9. Which of the following descriptions apply to the nuclear reactions that produce energy at the core of the Sun?

I	Heavy unstable nuclei split apart into two smaller nuclei.
II	Lightweight nuclei release energy when they join to form one nucleus.
III	The reaction produces products that are radioactive.

- A. I only  
 B. II only  
 C. I and III only  
 D. II and III only
10. All of the following are concerns connected with the use of CANDU nuclear reactors. Three of these concerns are considered by nuclear regulators to be of very low risk because technologies and procedures have been implemented to deal with them. Which of these four concerns represents a problem for which no generally accepted solution has been reached?
- A. The nuclear reactor might have a runaway chain reaction and lead to a meltdown of the reactor core.  
 B. The nuclear waste produced in the process might be stolen to produce nuclear weapons.  
 C. The nuclear waste lasts millions of years and might leak out into the environment over time.  
 D. Radioactive isotopes might be emitted during normal operation and harm people working at the facility and those living nearby.

<b>Match the Term on the left with the best Descriptor on the right. Each Descriptor may be used only once.</b>	
<b>Term</b>	<b>Descriptor</b>
_____ 11. beta particle	A. high energy electromagnetic radiation
_____ 12. gamma radiation	B. a process involving the joining together of two nuclei
_____ 13. mass number	C. a process involving the splitting of a large nucleus into smaller fragments
_____ 14. daughter isotope	D. the sum of the number of protons and neutrons in the nucleus of an atom
_____ 15. fusion	E. the time it takes for one half of a sample of a radioisotope to decay
_____ 16. half-life	F. a fast-moving electron that has been ejected from the nucleus of an atom
	G. a newly formed nucleus produced during a nuclear reaction
	H. a fast-moving helium nucleus that has been ejected from the nucleus of an atom

## Short Answer Questions

17. Potassium-39 and potassium-40 are isotopes. Refer to the subatomic particles that make up the atoms of these isotopes.

(a) How are these isotopes similar?

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(b) How are these isotopes different?

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(c) State which isotope is heavier than the other and explain why.

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18. If 200 micrograms (or 200 billionths of a gram) of carbon-14 were present in a sample of pollen, how many grams would be left after the following periods?

(a) 5730 years \_\_\_\_\_

(b) 14 600 years \_\_\_\_\_

(c) four half-lives \_\_\_\_\_

19. Provide the nuclear symbol for the parent nucleus for each.

(a) \_\_\_\_\_  $\rightarrow$   ${}_{85}^{207}\text{At}$  (alpha decay)

(b) \_\_\_\_\_  $\rightarrow$   ${}_{94}^{239}\text{Pu}$  (beta decay)

(c) \_\_\_\_\_  $\rightarrow$   ${}_{12}^{24}\text{Mg}$  (gamma decay)