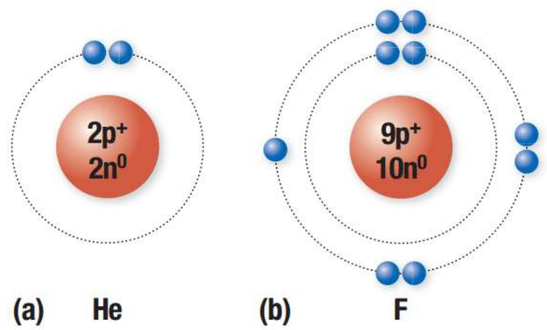
SPH3U 7.1 Atoms and Isotopes

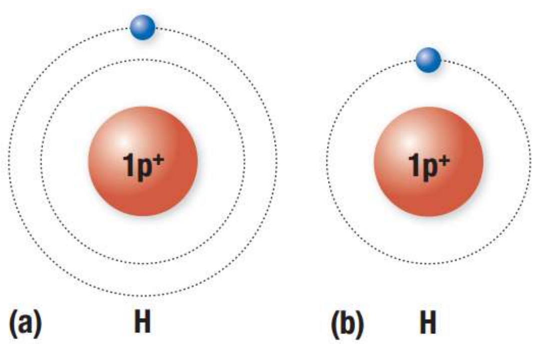
1. Bohr-Rutherford model of the atom

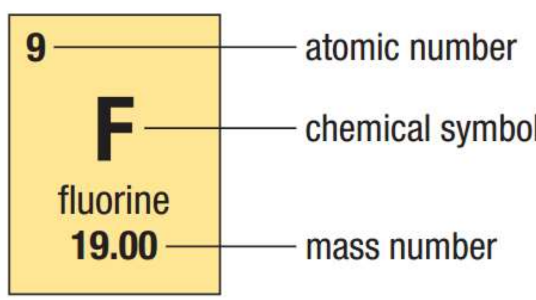
Nucleus:		Shells:	



Shell number	Maximum number of electrons
1	2
2	8
3	18
4	32

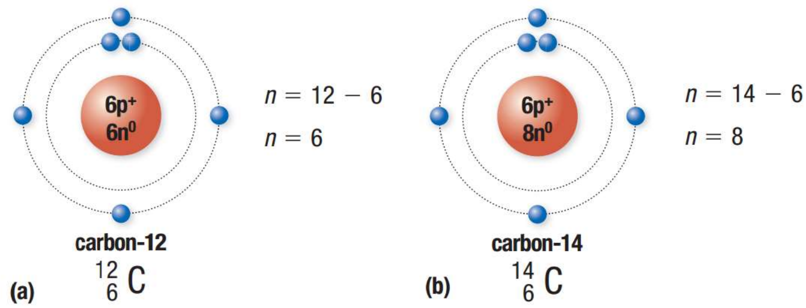
Excited state:		Atomic number:	
		Mass number:	





2. Isotopes

Isotope:	



Hydrogen:	
deuterium	
tritium	
Periodic table:	

Draw the Bohr-Rutherford diagram for silicon-31.

3. Medical applications of radioisotopes

Radioisotopes:	
nuclear medical imaging	
radionuclide therapy (RNT)	

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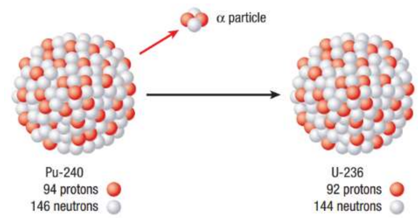
SPH3U 7.2 Radioactive Decay

1. Radioactivity

Radioactivity:	
stable atom	
atomic #	
3 types of decay	

2. Alpha (α) decay

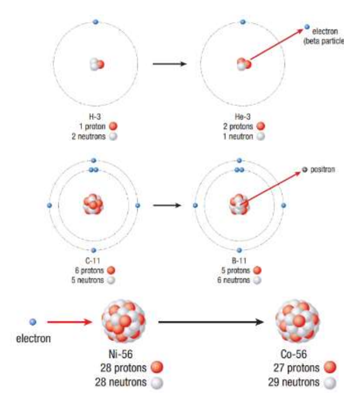
Alpha decay:	
α particle	
plutonium-240 decay	
general alpha decay	
X and Y	



When lead-204 undergoes alpha decay, it produces a stable isotope. Determine the element and its atomic number and mass number. Write the nuclear reaction equation.

3. Beta (β) decay

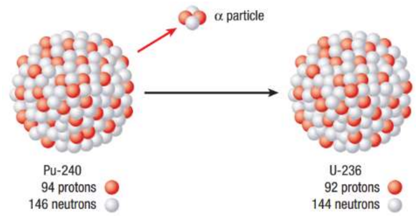
Beta decay:	
β particle	
Beta-negative decay:	
tritium H-3 decay	
Beta-positive decay:	
carbon-11 decay	
Electron capture:	
Ni-56 decay	



When bismuth-214 undergoes beta-negative decay, it produces a stable isotope. Determine the element and its atomic number and mass number. Write the nuclear reaction.

4. Gamma (γ) decay

Gamma decay:	
γ ray	
He-3 decay	
general gamma decay	
excited state	



When dysprosium-152 undergoes gamma decay, its nucleus changes from an excited state to a stable state. Write the nuclear reaction equation for this gamma decay.

5. Characteristics of radioactive decay

Danger of radiation:	

Decay	Radiation	Electric charge	Penetrating ability
alpha			
beta-negative			
beta-positive			
electron capture			
gamma			

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SPH3U 7.3 Half-Life

6. Half-life

Half-life:	
Rate of decay	
equation	

Neon-19 has a half-life of 17.22 s. What mass of neon-19 will remain from a 100 mg initial sample after 30 s?

A 100 mg sample of magnesium-27 decays by 7% of its previous mass every minute. Determine its half-life and state the half-life decay equation.

Time (min)	Initial mass (mg)	Final mass (mg)
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

7. Applications of half-life: Carbon dating

Carbon-14:	
carbon-14 decay	
carbon-14 absorption	
application	

Aluminum-26:	
al-26 decay	
application	

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SPH3U 7.4 Nuclear Fission

8. Mass-energy equivalence

Mass-energy equation:	
c	
Law of conservation of mass-energy:	

Particle	Mass (kg)	Mass (u)
proton	$1.672\,6014 \times 10^{-27}$	1.007 276
neutron	$1.674\,920 \times 10^{-27}$	1.008 665
electron	$9.109\,56 \times 10^{-31}$	0.000 549

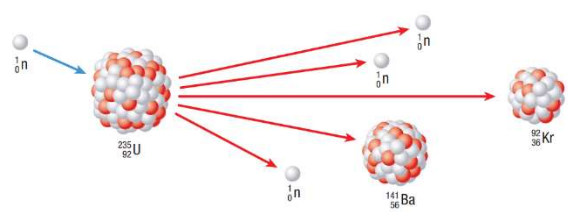
Atomic mass unit (u):	
Mega-electron volt:	

Mass defect:	
Binding energy:	

Determine the mass defect and binding energy of a lithium-7 nucleus, given that its actual atomic mass is 7.016 00 u, and using the particle mass table above.

9. Nuclear fuel

U-235 fission:	${}^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{92}_{36}\text{Kr} + {}^{141}_{56}\text{Ba} + 3({}^{1}_{0}\text{n})$
Chain reaction:	



Other nuclear fuels:	

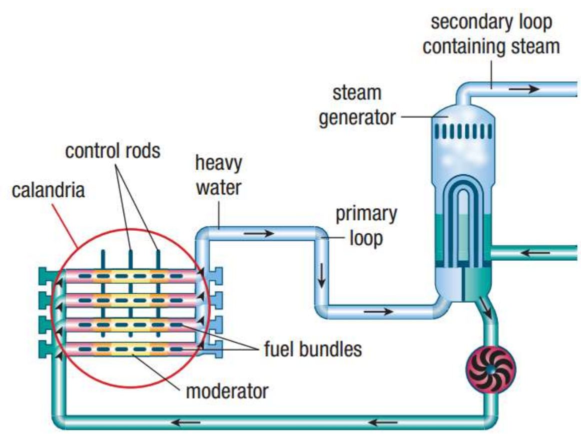
What is the energy yield of the following fission reaction? Use the given masses below.

$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{140}_{55}Cs + ^{93}_{37}Rb + 3(^{1}_{0}n)$

mass of U (m_U) = 235.044 u
mass of Cs (m_{Cs}) = 139.909 u
mass of Rb (m_{Rb}) = 92.922 u
mass of neutron (m_n) = 1.009 u

10. CANDU Reactors

Neutron moderation:	
Natural uranium:	
Radiation badges:	
Waste disposal:	



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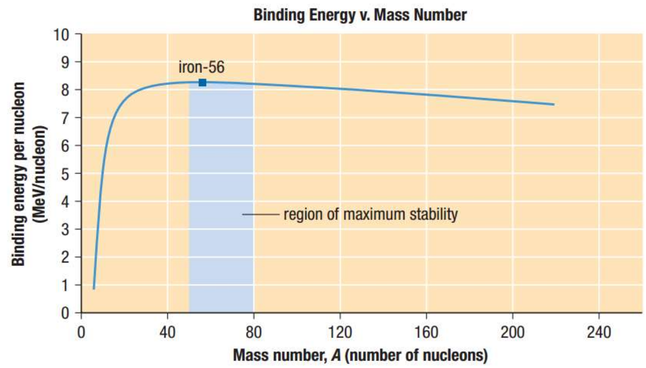
SPH3U 7.5 Nuclear Fusion

11. Mass-energy equivalence

Heavy nuclei:	
Light nuclei:	
c^2:	



Determine the energy released when a deuterium atom (D) fuses with a tritium atom (T) to form helium, according to the nuclear reaction equation below. Use the given masses.

$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n + \text{energy}$

m_D = 2.014 10 u m_{He} = 4.002 60 u c^2 = 930 MeV/u
m_T = 3.016 05 u m_n = 1.008 67 u

12. Controlled nuclear fusion

Proton-proton chain:	
Production of elements:	
Carbon-nitrogen-oxygen cycle:	
Magnetic confinement:	
The ITER Project:	

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