

CHAPTER 22 CONT

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## 22.6 NUCLEAR FISSION & FUSION

- Nuclear Reactors
  - Same fission as bombs, but controlled
    - Containment vessel surrounded by circulating coolant
    - Control Rods – boron or cadmium
      - Absorb neutrons (regulate flow)
      - Lowered and raised – barely self-sustainable rate
    - Energy heats coolant → steam drives turbine (electricity)
    - UO<sub>2</sub> pellets w/ 3% <sup>235</sup>U encased in zirconium rods
      - Pressure system filled with water (control neutrons)
    - Controls & small amounts don't make a bomb, but can have overheating and thus meltdown
    - 21% of world's power
      - Problem waste disposal

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## 22.6 NUCLEAR FISSION & FUSION

- Nuclear Fusion
  - Light nuclei combining
    - H → He
  - Fusion powers our sun
    - ${}^1_1\text{H} + {}^1_1\text{H} \rightarrow {}^2_1\text{H} + {}^0_1\text{e}$
    - ${}^1_1\text{H} + {}^2_1\text{H} \rightarrow {}^3_2\text{He}$
    - ${}^2_2\text{He} + {}^2_2\text{He} \rightarrow {}^4_2\text{He} + 2{}^1_1\text{H}$
    - ${}^2_2\text{He} + {}^1_1\text{H} \rightarrow {}^3_2\text{He} + {}^0_1\text{e}$

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## 22.6 NUCLEAR FISSION & FUSION

- Fusion Cont.
  - Fusion as a power source
    - Hydrogen isotopes cheap and plentiful
    - No radioactive waste
  - 1 of many problems with fusion as a power source
    - T = 40,000,000 K needed (yikes!)
    - Would cold fusion be possible?

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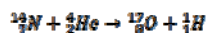
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## 22.7 NUCLEAR TRANSMUTATION

- <300 of 3600 known isotopes occur naturally
  - Nuclear Transmutation – change of one element into another
    - Bombard atom with high energy particle (p, n, or  $\alpha$ )
      - Unstable nucleus momentarily created
      - Nuclear change
      - Different element produced
      - 1<sup>st</sup> done in 1917




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## 22.7 NUCLEAR TRANSMUTATION

- Atomic Numbers > 92 developed from transmutation
  - Plutonium from U-238 and  $\alpha$ -particles
    - Pu decays by  $\beta$ -emission
    - Produces americium (used in smoke detectors)
  - Cobalt-60 used for cancer treatment
    - Neutron bombardment of iron-58
  - Balancing nuclear transmutation equations: Example
    - $\alpha$  – bombardment of Americium-241 produces berkelium and 2 neutrons. Write the nuclear reaction.
    - What isotope of Bk is produced?

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## 22.8 DETECTING AND MEASURING

- Ionizing Radiation – high E radiation
  - Knocks electron off a molecule
    - Also includes x-rays & cosmic rays
  - Film badge worn
  - Geiger counter
  - Scintillation counter – lab
  - Units for measuring (see table 22.3 p924)

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## 22.8 DETECTING AND MEASURING

Radiation Measurements				
	Radioactivity	Absorbed Dose	Dose Equivalent	Exposure
<b>Common Units</b>	curie (Ci)	rad	rem	roentgen (R)
<b>SI Units</b>	becquerel (Bq)	gray (Gy)	sievert (Sv)	coulomb /kilogram (C/kg)

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## 22.8 DETECTING AND MEASURING

Conversion Equivalence	
1 curie = $3.7 \times 10^{10}$ disintegrations per second	1 becquerel = 1 disintegration per second
1 millicurie (mCi)	= 37 megabecquerels (MBq)
1 rad	= 0.01 gray (Gy)
1 rem	= 0.01 sievert (Sv)
1 roentgen (R)	= 0.000258 coulomb/kilogram (C/kg)
1 megabecquerel (MBq)	= 0.027 millicuries (mCi)
1 gray (Gy)	= 100 rad
1 sievert (Sv)	= 100 rem
1 coulomb/kilogram (C/kg)	= 3,880 roentgens

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## 22.9 BIOLOGICAL EFFECTS OF RADIATION

- Effects vary on type and amount
  - More penetrating more dangerous
  - Internal VS External
    - $\alpha$  really bad internally
    - $\alpha$  stopped with paper
    - $\beta$  stopped with protective clothing
    - $\gamma$  & X-rays - lead needed to stop
  - Normal 0.120 rem per year

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## 22.10 APPLICATIONS

- Dating:
  - Radiocarbon dating
    - Neutron bombardment of N-14 in upper atmosphere
      - Produces C-14
      - Enters lower atmosphere as CO<sub>2</sub>
      - Taken in by organisms – C-12 to C-14 stays constant until organism dies
      - C-14 decays via beta emission
      - The ratio of C-14 to C-12 allows for dating
      - Age given in year BP (before present ~1950)
    - U-238 and K-40 can be used to date rocks
      - Age of earth 4.5 billion years

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## 22.10 APPLICATIONS

- Radiocarbon dating example:
  - An artifact found to have a <sup>14</sup>C decay rate of 14.2 disintegrations/min per gram of carbon. What age BP is implied by the result if currently living organisms decay at the rate of 15.3 disintegrations/min per gram of carbon? The half-life of C-14 is 5730 years.

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**22.10 APPLICATIONS**

- Medical Uses:
  - 1) In vivo procedures: (inside body)
    - Whole-blood volume – red blood cells labeled with Cr-51
      - Measure sample dilution
  - 2) Therapeutic Procedures:
    - Kill disease or tissue
    - Internal or external
  - 3) Imaging Procedures:
    - Injected with radio-marker
      - Scanned using radiation detectors
    - MRI – magnetic resonance imaging
      - Radio waves in presence of magnetic field stimulate H nuclei in water
        - Give off signal that can be measured

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**THE END ☺**

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