Midterm 2 Review: Solutions

NOTE: These review sheets cover only selected topics from Chapters 8-13 and are not meant to be a comprehensive review. Topics included in Chapters 8-13 that are not included on these review sheets may appear on the midterm exam.

Chapter 8: Chemical Energy

1) Endothermic and exothermic reactions

a) Exothermic reactions give off energy. List examples of different forms of energy released by chemical exothermic reactions.

Some examples seen in class: thermal energy (hot pack), visible light (glow sticks), electrical energy (batteries)

b) Endothermic reactions take in energy. What are some indicators that a reaction is endothermic? Give examples.

An object feels cold or its temperature decreases (cold pack)

A reaction absorbs more energy than it gives off. (Green plants absorb radiant energy from the sun for photosynthesis.)

A reaction requires a continuing energy input (electroplating, electrolysis of water)

c) Can a reaction that requires an initial input of activation energy be exothermic? Give an example to support your answer.

Yes. Lighting a candle requires an input of energy from a match or lighter. However, the reaction of burning the candle is exothermic because more energy is given off when the candle burns than is put in to light it.

2) Chemical binding energy

A chemical reaction required 20 joules of energy to break the existing chemical bonds and released 45 joules of energy. The reaction was

a) exothermic and took in 25 joules of energy.
b) endothermic and released 25 joules of energy.
c) endothermic and took in 20 joules of energy.
d) exothermic and released 45 joules of energy.
e) **exothermic and released 25 joules of energy**.

Another chemical reaction required 50 joules of energy to break the existing chemical bonds, but 30 joules of energy were given off when new bonds were formed. The reaction was

a) endothermic and took in 50 joules of energy.
b) endothermic and released 30 joules of energy.
c) exothermic and released 30 joules of energy.
d) exothermic and took in 50 joules of energy.
e) **endothermic and took in 20 joules of energy**.

Chapter 9: Chemical Energy

3) Nuclear Reactions

a) How can an atom of one element change into an atom of a different element?

Protons can be added to or removed from atomic nuclei. A neutron in the nucleus can be changed into a proton, or a proton can be changed into a neutron.

b) Write the equation for the nuclear reaction that occurs when a neutron emits an electron and becomes a proton.

$${}^{1}_{0}\mathbf{n} \rightarrow {}^{1}_{1}\mathbf{p} + {}^{0}_{-1}\mathbf{e}^{-} + {}^{0}_{0}\bar{\nu}$$, **where $\bar{\nu}$ denotes an antineutrino**

c) Write the equation for the nuclear reaction that occurs when a proton emits an antielectron and becomes a neutron.

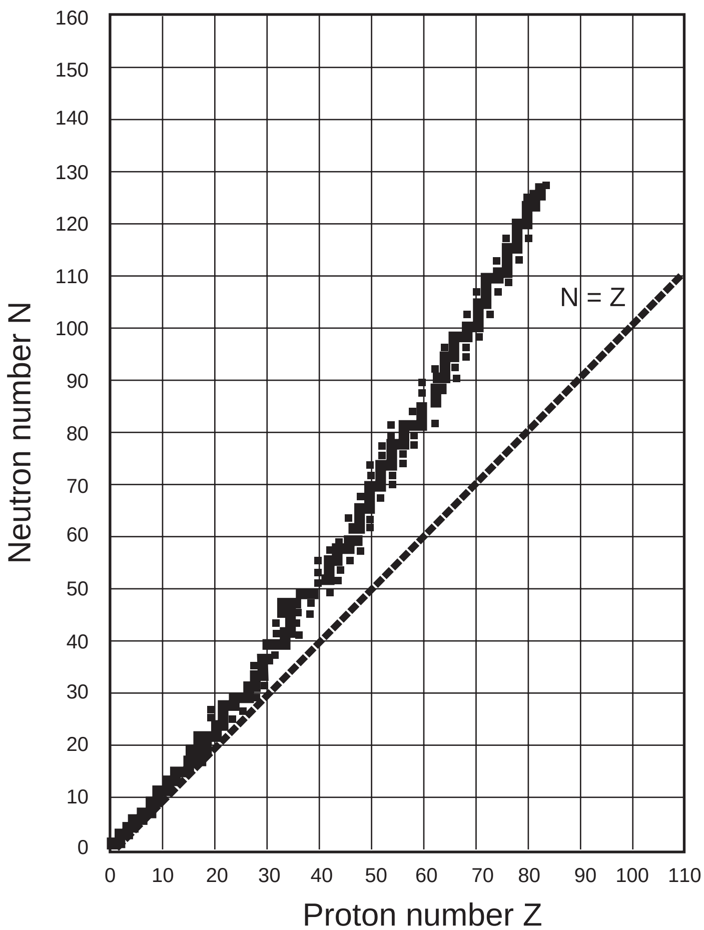
$${}^{1}_{1}\mathbf{p} \rightarrow {}^{1}_{0}\mathbf{n} + {}^{0}_{1}\mathbf{e}^{+} + {}^{0}_{0}\nu$$

d) A nucleus of iron-56 (${}^{56}_{26}Fe$) has how many protons? __**26**___

How many neutrons does this nucleus have? _**56-26 = 30**__

How many nucleons does the nucleus have? __**56**__

4) Graph of Stable Nuclei



a) According to the graph, would a nucleus with 70 protons and 70 neutrons be stable? Why or why not?

Unstable. Large stable nuclei have more neutrons than protons.

b) Would a nucleus with 80 neutrons and 40 protons be stable? If not, what change could make this nucleus stable?

Unstable. To make the nucleus stable, neutrons must decay into protons.

c) Would a nucleus with 70 neutrons and 50 protons be stable? If not, what change could make this nucleus stable?

Stable. (You can tell this nucleus is stable because it lies within the shaded region of the graph.)

Chapter 10: Ionizing Radiation I

5) Summary of ionizing radiation

Fill in the table below, which summarizes the properties of the types of ionizing radiation.

Radiation	Particle emitted	A = # of nucleons	Z = # of protons	Electric Charge
alpha (α)	**helium nuclei ($^{4}_{2}He$)**	**4**	**2**	**+2**
beta (β^{-})	**electron (e^{-})**	**0**	**0**	**-1**
beta (β^{+})	**antielectron (e^{+})**	**0**	**0**	**+1**
gamma (γ)	**high energy photon**	**0**	**0**	**0**

6) Decay of unstable isotopes

a) Potassium-40 ($^{40}_{19}K$) is unstable. Why is this nucleus unstable?

It is a small nucleus with more neutrons (21) than protons (19).

What change in nucleons could make this nucleus stable?

Beta-minus decay would change one neutron into a proton.

Write the nuclear reaction that shows this nucleus decaying to a stable nucleus.

$$^{40}_{19}K \rightarrow {}^{40}_{20}Ca + {}^{0}_{-1}e + {}^{0}_{0}\overline{\nu}$$

b) Thorium-232 ($^{232}_{90}Th$) is unstable. Why is this nucleus unstable?

It is a large nucleus with more than 83 protons.

What change could make this nucleus more stable?

Alpha decay would reduce the number of protons.

Write an equation that describes this nuclear reaction.

$$^{232}_{90}Th \rightarrow {}^{228}_{88}Ra + {}^{4}_{2}He$$

c) Oxygen-14 ($^{14}_{8}O$) is unstable. Why is this nucleus unstable?

It is a small nucleus with more protons (8) than neutrons (6).

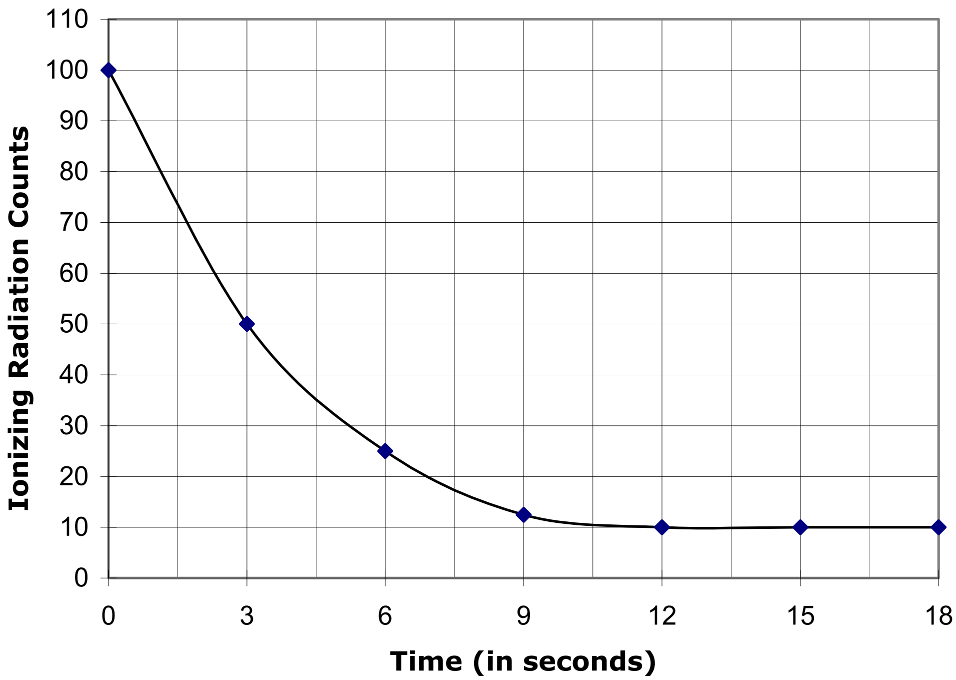
What change in nucleons could make this nucleus more stable?

Beta-plus decay would change one proton into a neutron.

Write the nuclear reaction that shows this nucleus decaying to a stable nucleus.

$$^{14}_{8}O \rightarrow {}^{14}_{7}N + {}^{0}_{+1}e + {}^{0}_{0}\nu$$

7) Graph of radioactive decay of an unstable isotope



a) How large is the background radiation illustrated by the graph? **10 counts/second**

b) What is the half life of this unstable isotope?

1) Pick a point on the graph: **100 cts/sec**
2) Subtract the background counts: **100 cts/sec – 10 cts/sec = 90 cts/sec**
3) Divide the result by 2: **90 cts/sec /2 = 45 cts/sec**
4) Add the background counts: **45 cts/sec + 10 cts/sec = 55 cts/sec**
5) Find this point on the graph and read off the time elapsed.

approximately 2.1 seconds

8) Carbon Dating

The carbon-14 level in a sample of charcoal found at an archeological site is 1/8 of what it was when the wood that formed the charcoal was living. How old is this site? (The half life of carbon-14 is 5,730 years.)

$1/8 = 1/2^3$, so 3 half-lives have passed.

(3 half lives) x (5,730 yrs/ half life) = 17,190 yrs

Chapter 11: Ionizing Radiation II

9) Formation of nucleons

a) Nucleons consist of quark trios. The electric charge of an up quark = + 2/3, and the charge of a down quark = – 1/3.

Which 3 quarks could combine to form a proton?

2 up quarks + 1 down quark give a total electric charge of

2 (+2/3) – 1/3 = +1

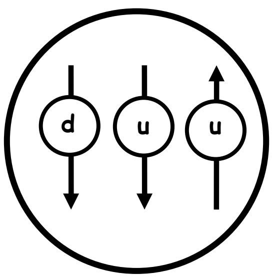
Which 3 quarks could combine to form a neutron?

1 up quark + 2 down quarks give a total electric charge of

+2/3 + 2(– 1/3) = 0

b) The intrinsic spin of each quark = ½. The spins of two quarks of the same type must point in opposite directions.

Draw a diagram showing the quarks that make up a proton and their spins.



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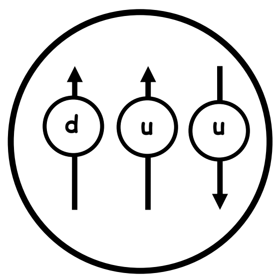
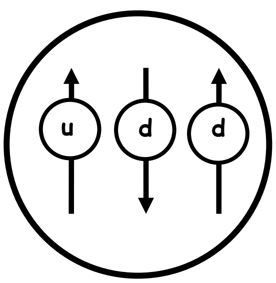


Draw a diagram showing the quarks that make up a neutron and their spins.



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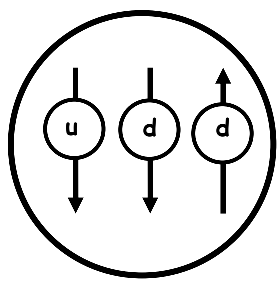
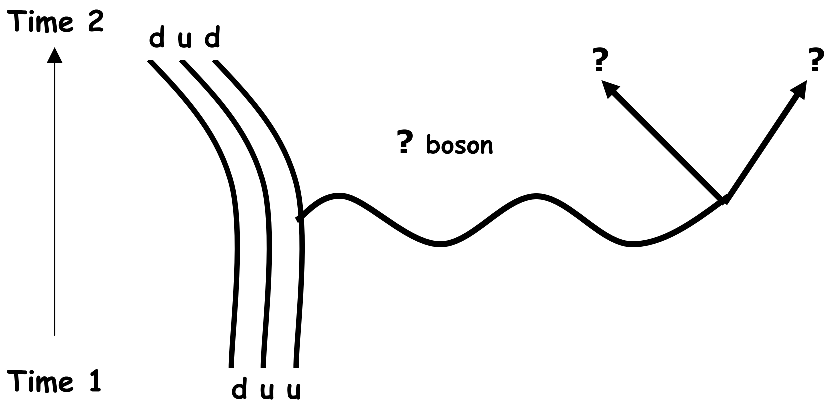


10) Feynman Diagram of a Beta Decay Beta decays can be represented by a Feynman diagram.



a) In the diagram above, which type of nucleon existed at Time 1? **a proton because the nucleon consists of 2 up quarks and 1 down quark**

Which type existed at Time 2? **a neutron because the nucleon consists of 1 up quark and 2 down quarks**

b) Write the nuclear reaction that illustrates the change of nucleon from Time 1 to Time 2.

$$^{1}_{1}\mathbf{p} \rightarrow \ ^{1}_{0}\mathbf{n} + \ ^{0}_{+1}\mathbf{e} + \ ^{0}_{0}\nu$$

c) Which type of beta decay is this? **an antielectron is emitted, so this is beta plus decay**

d) Which gauge boson is involved in this type of decay?

the W^+ boson is involved in beta-plus decay

11) Fundamental Forces and bosons Fill in the chart with information on bosons.

Fundamental Force	Exchange Boson	Purpose
Strong Nuclear	**Gluons**	1) **Binds quarks to form neutrons and protons.** 2) **Binds quarks and antiquarks to form pions. Nucleons exchange pions to bind into nuclei.**
Electromagnetic	**Gamma boson**	**Binds charged particles together.**
Weak Nuclear	**W^+, W^-, and Z^0**	**Beta-minus decay turns a neutron into a proton. Beta-plus decay turns a proton into a neutron.**
Gravitational	**Graviton (?)**	**Allows mater to clump together.**

Chapter 12: Nuclear Reactions

12) Binding energy calculations

When protons and neutrons bind into a nucleus, the mass of the nucleus is slightly less than the mass of the protons and neutrons that make up that nucleus. This difference is the mass that has been converted into energy: $E = mc^2$. This is the binding energy of the nucleus.

a) An iron nucleus ($^{56}_{26}Fe$) has a mass of 92.8596×10^{-27} kg. Find the binding energy of this nucleus.

1. Find the mass of the protons that make up this nucleus. proton mass = $M_p = 1.6726 \times 10^{-27}$ kg

   $$\mathbf{26\ (1.6726 \times 10^{-27}\ kg) \quad = \quad 43.4876 \times 10^{-27}\ kg}$$

   Find the mass of the neutrons that make up this nucleus. neutron mass = $M_n = 1.6749 \times 10^{-27}$ kg

   $$\mathbf{30\ (1.6749 \times 10^{-27}\ kg) \quad = \quad 50.2470 \times 10^{-27}\ kg}$$

2. Find the total mass of the nucleons that make up the nucleus.

   $$\begin{array}{r} \mathbf{43.4876 \times 10^{-27}\ kg} \\ \mathbf{+\ \underline{50.2470 \times 10^{-27}\ kg}} \\ \mathbf{93.7346 \times 10^{-27}\ kg} \end{array}$$

3. Subtract the known mass, 92.8596×10^{-27} kg, from the total mass of the nucleons you calculated. This difference in mass is the amount of mass that was converted into energy when the nucleus formed.

   $$\begin{array}{r} \mathbf{93.7346 \times 10^{-27}\ kg} \\ \mathbf{-\ \underline{92.8596 \times 10^{-27}\ kg}} \\ \mathbf{0.8750 \times 10^{-27}\ kg} \end{array}$$

4. Find the binding energy, using $E = Mc^2$. The variable M is the difference in mass calculated in step #3.

   $$\mathbf{E = \ (0.8750 \times 10^{-27}\ kg) \times (3 \times 10^{8}\ m/s)^2}$$

   $$\mathbf{E = \ (0.8750 \times 10^{-27}\ kg) \times (9 \times 10^{16}\ m^2/s^2) \ = \ 7.875 \times 10^{-11}\ J}$$

13) Hertzsprung-Russell (H-R) diagram

a) On an H-R diagram, why does the color of the main sequence stars change as one moves from the left to the right of the diagram?

The color of stars is related to the star's surface temperature. Higher temperature stars radiate more energetic photons with shorter wavelengths. Cooler stars radiate longer wavelength photons. As a result, star colors range from blue for the hottest stars to red for the cooler stars.

b) What are the large red stars in the upper right corner of the diagram? What is formed when these stars explode?

These red giant stars have collapsed and their mantle of matter has blown outward. When these stars collapse and explode violently in a type II supernova, elements heavier than iron are fused and blown into the Universe.

Chapter 13: Astrophysics

14) Evolution of the Universe

Arrange the following events in the early Universe in chronological order starting with the earliest event:

(5) sudden expansion of the Universe
(4) condensation of quarks and leptons
(6) formation of protons and neutrons
(3) condensation of the fundamental forces
(1) the Big Bang
(7) fusion of deuterium (helium nuclei)
(2) formation of photons

15) The expansion and age of the Universe

a) What is meant by the red shift of starlight?

The Doppler shift of light from a receding source shifts the photons emitted by the source to a longer wavelength. In the case of photons of visible light, the light appears reddened.

b) What does the red shift of light from galaxies tell us about the motion of galaxies and the size of the Universe?

Red shifted star light indicates that the galaxy containing the star is receding from the Earth. This is evidence that the Universe is expanding.

c) How can the Hubble constant be found? How is the Hubble constant used to estimate the age of the Universe?

The Hubble constant (H_o) is the slope of graph of the velocity at which a galaxy is receding versus the distance of the galaxy. The age of the Universe can be estimated by the inverse of the Hubble constant: $1/H_o$