

**Physics/Global Studies 280**  
**Nuclear Weapons, Nuclear War, and Arms Control**

**Midterm Examination**

**2009 March 19**

Full Name \_\_\_\_\_

UIUC ID No. \_\_\_\_\_

- This is a closed book examination—you are not to consult any materials other than the exam itself, or any person. Giving or receiving unauthorized help is a violation of the University's rules on academic integrity.
- You will have 90 minutes to complete it.
- Answer all the questions on all 10 topics. Each topic counts 20 points.
- The point value of each question within a topic is indicated by a boldface number in square brackets, e.g., **[2]**.
- Write your answers in the spaces provided below each question. *Do not submit any additional pages.* If you need more room, write on the back of the preceding page.
- To receive full credit for definitions, give numbers where relevant.

**Scores**

1. \_\_\_\_\_ **[20]**

6. \_\_\_\_\_ **[20]**

2. \_\_\_\_\_ **[20]**

7. \_\_\_\_\_ **[20]**

3. \_\_\_\_\_ **[20]**

8. \_\_\_\_\_ **[20]**

4. \_\_\_\_\_ **[20]**

9. \_\_\_\_\_ **[20]**

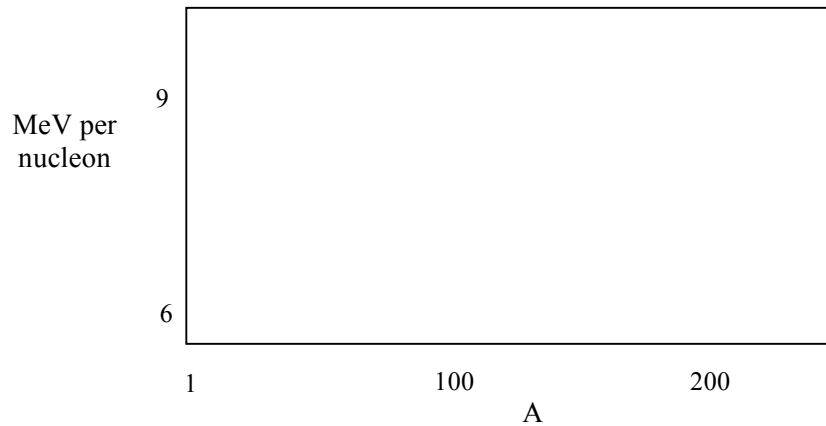
5. \_\_\_\_\_ **[20]**

10. \_\_\_\_\_ **[20]**

Total \_\_\_\_\_ **[200]**

**1. Nuclear physics [20]**

- (a) In the panel below, sketch the curve of binding energy per nucleon from  $A=1$  to  $A=240$ . [4]



- (b) What are the two fundamental forces responsible for the shape of this curve? [2]
- (c) Which part of diagram above is relevant for nuclear fission reactions? [2]
- (d) Which part of diagram above is relevant for nuclear fusion reactions? [2]
- (e) What is the definition of a nuclear-explosive nuclide? [2]
- (f) Are all fissile nuclides nuclear-explosive nuclides? [1]
- (g) Are there any nuclear-explosive nuclides that are not fissile? [1]
- (h) What is the definition of a fertile nuclide? [2]
- (i) What is the definition of nuclear-explosive material? [2]
- (j) Can the timing of a spontaneous fission event be controlled? [2]

**2. Nuclear-explosive materials [20]**

- (a) What isotope of uranium is most common in nature? Is it nuclear-explosive? [2]
- (b) Define the following uranium materials: [6]
- i. low-enriched-uranium –
  - ii. highly-enriched uranium –
  - iii. weapon-grade uranium –
- (c) Different isotopes of uranium cannot be separated using chemical processes. Why not? [2]
- (d) Define the following nuclear materials in terms of the percentage of Pu-239: [4]
- i. reactor-grade plutonium –
  - ii. weapon-grade plutonium –
- (e) What is the currently preferred technology for producing weapon-grade uranium? [6]

List two characteristics of this technology that make it preferable to others, for this purpose.

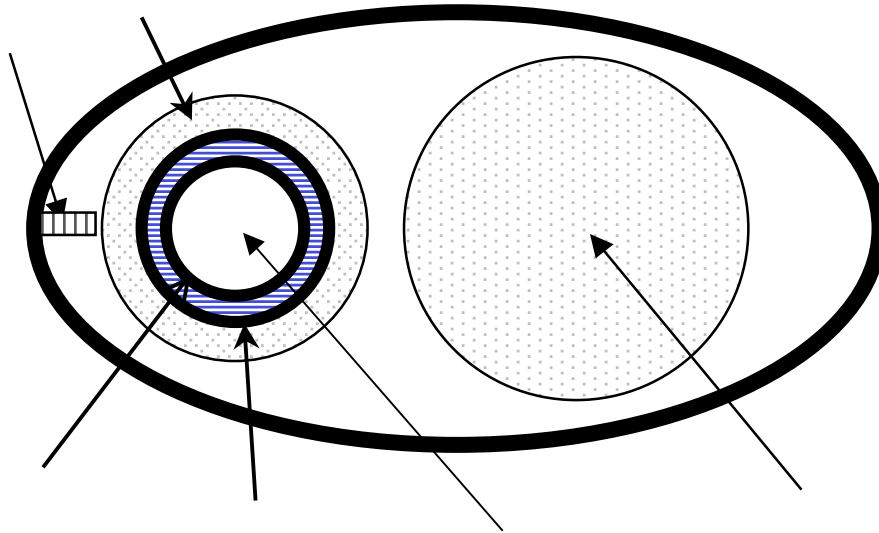
- i.
- ii.

**3. Nuclear explosions [20]**

- (a) What is the definition of the neutron multiplication factor for a configuration of nuclear material? [2]
- (b) What is the numerical value of the neutron multiplication factor for [6]
- i. a sub-critical configuration of nuclear material –
  - ii. a critical configuration of nuclear material –
  - iii. a super-critical configuration of nuclear material –
- (c) List two things that can happen to a neutron released in a fission event in nuclear-explosive material that will prevent it from causing a subsequent fission event. [4]
- i.
  - ii.
- (d) List two properties of reactor-grade plutonium that complicate its use as a nuclear-explosive material. [4]
- i.
  - ii.
- (e) Is it possible to make a functioning a nuclear weapon using reactor-grade plutonium? [2]
- (f) Is there any fundamental limit to the yield of a fusion weapon? [2]

#### 4. True thermonuclear weapons [20]

- (a) Shown below is a simplified schematic diagram of a true thermonuclear weapon. Number the arrows in the diagram from 1 to 6 to indicate the locations of the following major weapon components: [1] the neutron-emitting initiator, [2] the high-explosive lens assembly, [3] the tamper/reflector, [4] the hollow shell (“pit”) made of nuclear-explosive material, [5] the boost gas (present when the weapon is detonated), and [6] the fusion packet. [6]



Answer the following questions in a single sentence.

- (b) What is the “primary” and why is it called this? [2]
- (c) What is the “secondary” and why is it called this? [2]
- (d) What is the function of the high-explosive lens assembly? [2]
- (e) What is the function of the tamper/reflector? [2]
- (f) What is the function of the initiator? [2]
- (g) What does the boost-gas do? [2]
- (h) What role does the bomb casing play if it is made of depleted uranium? [2]

**5. Nuclear weapon effects [20]**

- (a) State in one sentence the definition of an airburst. [1]
- (b) State in one sentence the definition of a surface burst. [1]
- (c) List the four principal harmful physical phenomena produced by a 1-Mt airburst in the order they would be experienced by a person located 3 miles from the center of the explosion. State the main harmful effect of each on a person exposed to them. [8]
- - 
  - 
  -
- (d) When the energy released in a nuclear explosion is stated in “kilotons”, with what is it being compared? [2]

Answer the following question by circling the right answer(s).

- (e) Which of the following are *nuclear* radiations? [4]

Radio      Optical      Alpha      Beta      Gamma      Neutron      X-ray

- (f) The *relative biological effectiveness* (RBE) indicates the biological damage produced by a given physical dose of radiation. The RBE depends on three factors. List two of them. [4]
- i.
  - ii.

**6. Characteristics of terrorism [20]**

(a) Give one-sentence definitions of each of the following terms: **[8]**

i. Terrorism

ii. State terrorism

iii. State-sponsored terrorism

iv. War terrorism

(b) The following paragraphs are taken from a New York Times article on the meaning of terrorism. Circle phrases or sentences that state or imply a definition of terrorism, note whether the definition is correct or incorrect, and indicate why. **[6]**

*The perception gap, which grew wider when President George W. Bush declared his war on terror in 2001, was blown even further apart in Gaza, when most Arabs came away certain who the real terrorists were.*

*“Public opinion views what happened in Gaza as a kind of terrorism,” said Muhammad Shaker, a former Egyptian ambassador to Britain. “And on the other side, they see Hamas and other such organizations as groups who are trying to liberate their countries.”*

*Many here said they saw little distinction between Hamas’s shooting rockets into civilian areas of Israel and Israel’s shooting rockets into civilian areas of Gaza, even if Hamas militants were operating there or just hiding out.*

(c) Richardson argues that a “lethal cocktail” of three factors produces terrorism. List them. **[6]**

i.

ii.

iii.

**7. Nuclear terrorism [20]**

- (a) List two ways terrorists might be able to acquire nuclear-explosive material. [2]
- i.
  - ii.
- (b) List two ways terrorists might transport a nuclear weapon into the United States: [2]
- i.
  - ii.
- (c) A nuclear bomb might not be detected when scanned by a radiation detector. Why not? [2]
- (d) A further difficulty in screening for nuclear bombs is that some common innocuous substances are radioactive and cause false alarms. Name two such substances: [2]
- i.
  - ii.
- (e) In his book *Nuclear Terrorism*, Graham Allison lists three “No’s” that he argues must be accomplished to prevent nuclear terrorism. List them. [6]
- i.
  - ii.
  - iii.
- (f) In *Nuclear Terrorism*, Allison lists seven “Yes’s” that he argues must be accomplished to achieve his three “No’s”. List any three of his seven “Yes’s”. [6]
- i.
  - ii.
  - iii.



**8. Nuclear weapon delivery methods [20]**

- (a) Can a nuclear-armed bomber be recalled after it has been launched? (Yes or No) [2]
- (b) Can a nuclear-armed cruise missile be recalled after it has been launched? (Yes or No) [2]
- (c) Can a nuclear-armed ballistic missile be recalled after it has been launched? (Yes or No) [2]
- (d) Can a solid-propellant rocket engine be shut down after it has been started? (Yes or No) [2]
- (e) During the next few weeks, North Korea is expected to test a large rocket.
  - i. How many stages is it expected to have? [2]
  - ii. What direction is it expected to fly and what nearby country is it expected to fly over? [2]

Answer the following two questions in a phrase or sentence, as appropriate.

- (f) List two methods for delivering nuclear weapons that are among those the U.S. intelligence community assesses are most likely to be used to attack the territory of the U.S. [4]
  - i.
  - ii.
- (g) List two reasons an attacker is likely to prefer one of these methods over other methods. [4]
  - i.
  - ii.

**9. Missiles [20]**

(a) Decode the following initializations and list the ranges that define these missile types. **[8]**

i. ICBM

ii. SRBM

iii. MRBM

iv. IRBM

(b) Several significant design challenges must be overcome before a nuclear weapon can be reliably delivered by a long-range ballistic missile. Name three. **[6]**

i.

ii.

iii.

(c) Decode the following initializations and explain what they mean. **[6]**

i. MRV

ii. MIRV

iii. MARV

**10. Nuclear proliferation [20]**

(a) Which four countries once had nuclear weapons but gave them up? **[8]**

- i.
- ii.
- iii.
- iv.

(b) Which four countries have nuclear weapons but are not parties to the Nuclear Nonproliferation Treaty? **[8]**

- i.
- ii.
- iii.
- iv.

(c) Which two countries have waged preventive wars ostensibly to prevent an adversary from obtaining nuclear weapons? **[4]**

- i.
- ii.