

Last Name: \_\_\_\_\_ First Name \_\_\_\_\_ Network-ID \_\_\_\_\_

Writing Lab Section: \_\_\_\_\_ Writing Lab TA Name: \_\_\_\_\_

**Turn off your cell phone and put it out of sight.**

**Calculators cannot be used.**

**This is a closed book exam. You have eighty (80) minutes to complete it.**

1. Use a #2 pencil. Do not use a mechanical pencil or pen. Darken each circle completely, but stay within the boundary. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner. Be especially careful that your mark covers the **center** of its circle.
2. **This Exam Booklet is Version A.** Mark the **A** circle in the **TEST FORM** box near the middle of your answer sheet. **DO THIS NOW!**
3. Print your **NETWORK ID** in the designated spaces at the *right* side of the answer sheet, starting in the left most column, then **mark the corresponding circle** below each character. If there is a letter "o" in your NetID, be sure to mark the "o" circle and not the circle for the digit zero. If and only if there is a hyphen "-" in your NetID, mark the hyphen circle at the bottom of the column. When you have finished marking the circles corresponding to your NetID, check particularly that you have not marked two circles in any one of the columns.
4. Print **YOUR LAST NAME** in the designated spaces at the *left* side of the answer sheet, then mark the corresponding circle below each letter. Do the same for your **FIRST NAME INITIAL**.
5. Do not write in or mark the circles in any of the other boxes (STUDENT NUMBER, DATE, SECTION, SCORES, SPECIAL CODE).
6. Sign your name (**DO NOT PRINT**) on the **STUDENT SIGNATURE line**.
7. On the **SECTION line**, print your **Writing Lab Section**. You need not fill in the COURSE or INSTRUCTOR lines.

*Before starting work, check to make sure that your test booklet is complete. You should have 19 numbered pages..*

**Academic Integrity—Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including dismissal from the University.**

*Exam Grading Policy—*

The exam is worth a total of **320** points, composed of 4 types of questions.

**Rules for partial credit**

**Note: there will be no partial credit for problems with multiple correct answers. These problems are marked and all correct answers need to be marked correctly on the answer sheet in order to obtain credit.**

**MC5:** *multiple-choice-five-answer questions, each worth 6 points.*

**Partial credit will be granted as follows.**

- (a) If you mark only one answer and it is the correct answer, you earn **6** points.
- (b) If you mark *two* answers, one of which is the correct answer, you earn **3** points.
- (c) If you mark *three* answers, one of which is the correct answer, you earn **2** points.
- (d) If you mark no answers or the wrong answer, or more than *three*, you earn **0** points.

**MC4:** *multiple-choice-four-answer questions, each worth 4 points.*

**Partial credit will be granted as follows.**

- (a) If you mark only one answer and it is the correct answer, you earn **4** points.
- (b) If you mark *two* answers, one of which is the correct answer, you earn **2** points.
- (c) If you mark a wrong answer or no answers or more than two, you earn **0** points.

**MC3:** *multiple-choice-three-answer questions, each worth 3 points.*

**No partial credit.**

- (a) If you mark only one answer and it is the correct answer, you earn **3** points.
- (b) If you mark a wrong answer or no answers, you earn **0** points.

**MC2:** *multiple-choice-two-answer questions, each worth 2 points.*

**No partial credit.**

- (a) If you mark only one answer and it is the correct answer, you earn **2** points.
- (b) If you mark the wrong answer or neither answer, you earn **0** points

## A. Nuclear Physics

**Definitions.** The following table will be used for questions 1-6. The table lists 6 terms that need to be defined. Each row in the table corresponds to one question, 1-6. The 1<sup>st</sup> column lists for each questions the term to be defined. The 2<sup>nd</sup> column contains different possible definitions and an answer key for each question, A-E and AB. On your answer sheet bubble for each question the matching answer key from the 2<sup>nd</sup> column. The key “AB” requires to bubble both answers A and B. **[2 points each]**

|                        |   |
|------------------------|---|
| _____ 1) Atomic Weight | A. The number of protons in a nucleus   |
| _____ 2) Isotope       | B. A nuclide that can fission by bombardment with neutrons                                |
| _____ 3) Fertile       | C. A nuclide that can fission by neutrons of any energy                                   |
| _____ 4) Atomic Number | D. The total number of nucleons in a nucleus  |
| _____ 5) Fissionable   | E. Nuclides can be transformed into fissile nuclides through neutron capture              |
| _____ 6) Fissile       | AB. Different nuclides with the same number of protons, but different numbers of neutrons |

7) Which of the following particles are the basic building blocks of atomic nuclei? (**mark all correct answers**)

- A. electrons
- B. photons
- C. protons
- D. deuterons
- E. neutrons

8) How are U-235 and U-238 related? Both isotopes... (**mark all correct answers**)

- A. are found in nature.
- B. are fissile nuclides.
- C. have the same number of protons.
- D. have the same number of neutrons.
- E. have the same charge to mass ratio.

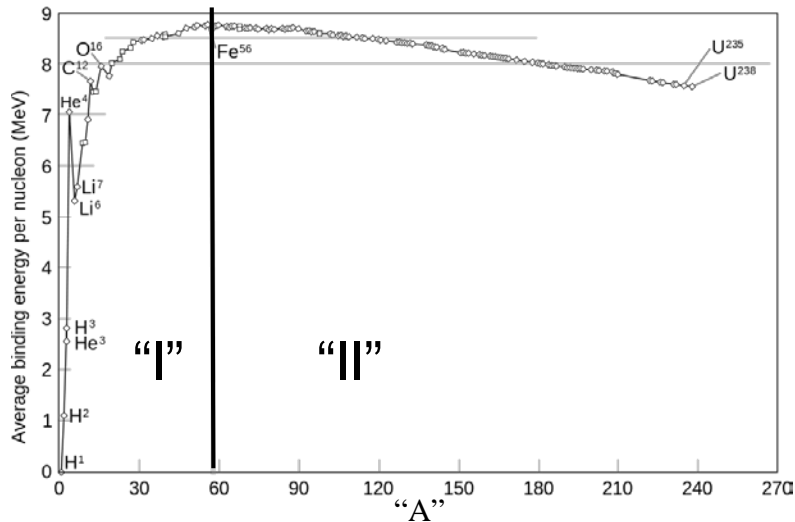
9) The nuclide  $^{206}_{82}\text{Pb}$  has...

- A. 82 neutrons and 206 protons  
 B. 82 neutrons and 124 protons  
 C. 124 neutrons and 82 protons  
 D. 206 neutrons and 82 protons

10) Nuclear Binding Energies compared to chemical binding energies are larger by a factor

- A. 10  
 B. 100  
 C. 1,000  
 D. 100,000  
 E. 1000,000

Use the graph of binding energies to answer questions 11-13.



11) The x-axis label "A" represents the number of...

- A. protons in the nuclide  
 B. neutrons in the nuclide  
 C. protons plus neutrons in the nuclide  
 D. neutrons minus protons in the nuclide

12) The region of binding energy graph where fusion can occur is...

- A. region "I" at small values of A  
 B. region "II" at large values of A  
 C. regions "I" and "II"  
 D. binding energy is not related to fusion

13) The region of binding energy graph where fission can occur is...

- A. region "I" at small values of A
- C. regions "I" and "II"
- B. region "II" at large values of A
- D. binding energy is not related to fission

### B. Nuclear weapons

14) What best describes the mechanism of an implosion-type weapon?

- A. Two sub-critical pieces of NEM combine to make a super-critical mass
- B. Radioactive material is dispersed using a conventional explosive
- C. A sub-critical configuration of NEM is compressed to make a super-critical mass
- D. A primary fission device ignites a secondary fusion charge

15) Why do gun-type weapons use U-235 for fuel?

- A. The critical mass for U-235 is smaller than that of Pu-239
- B. U-235 is easier to obtain than Pu-239
- C. U-235 has a slow rate of spontaneous fission and decay
- D. conventional explosives are only compatible with U-235

16) Where is the neutron initiator located in an implosion weapon?

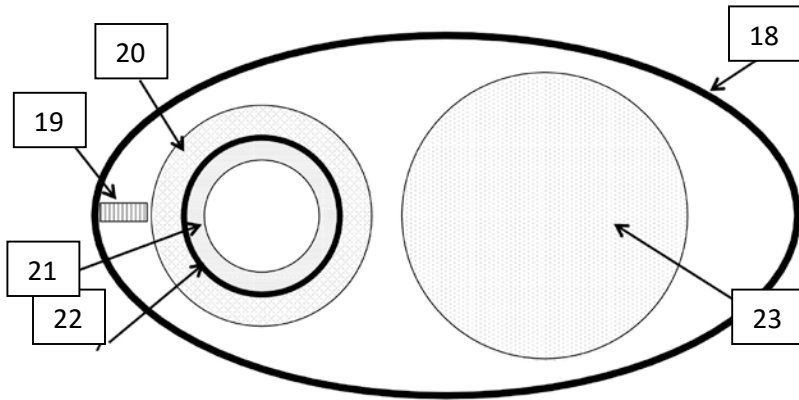
- A. Outside the ring of high-explosives
- B. Between the conventional explosive and the NEM
- C. At the center of the NEM "pit"
- D. There is no neutron initiator in an implosion weapon

17) What kind of radioactive material can be used in a "dirty bomb"?

- A. Only fissile material
- B. Any nuclear explosive material
- C. Any material that undergoes radioactive decay
- D. Any fissionable nuclide

Use the diagram of the thermonuclear bomb to answer questions 18-23.

**Labeling:** Match the weapon components identified by numbers, 18-23, with the correct answer keys, A-E and AB, provided in the list below. [2 points each]



- A. The neutron-emitting initiator
- B. The high-explosive lens assembly
- C. The tamper/reflector
- D. The hollow shell ("pit") of nuclear explosive material
- E. The depleted Uranium shell
- AB. The fusion packet

Each of the **Questions 18-23** should be answered with the correct answer key A-E and AB from the list above. The key "AB" requires to bubble both answers A and B.

24) What is the function of the initiator?

- A. Compresses the pit to start the chain reaction
- B. Provide additional neutrons to start the chain reaction
- C. Provide additional energy to maintain the chain reaction
- D. Keep the chain reaction from starting prematurely

25) What role does the bomb casing play if it is made of uranium?

- A. Start the fission reaction in the primary
- B. Contribute additional energy to the yield *via* fission reactions
- C. Add generations to the fission chain reaction
- D. Initiate the fusion reaction in the secondary

26) What is the theoretical maximum yield of a thermonuclear weapon?

- A. 100 kilotons
- B. 1 Megaton
- C. 50 Megatons
- D. There is none

**C. Current events**

- 27) What was the response of some South Korean politicians after the latest nuclear test by North Korea?
- A. They called for increasing the length of mandatory military service for South Korean men
  - B. They called for introducing mandatory military service for South Korean women
  - C. They called for the development of a South Korean nuclear arsenal
  - D. They called for sanctions on North Korea's allies in particular China and Vietnam
- 28) Why do some proponents argue that Minuteman missiles are still necessary part of the Triad?
- A. They are the most accurate of all America's nuclear forces
  - B. They serve as a "sink" for a potential nuclear attack
  - C. They are the most effective counters to missile deployments in Russia and Pakistan
  - D. They provide the best chance as second strike deterrent capability
- 29) What is the significance of the recent North Korean satellite launch test?
- A. The same missile which launched the satellite could be used as an ICBM
  - B. Satellite communications technology could be used for espionage and cyberwarfare
  - C. Satellite sensing technology is necessary for the deployment of nuclear weapons
  - D. The US has deemed it illegal for North Korea to have a space program
- 30) What breakthrough discovery was made by scientists by watching black holes collide?
- A. Einstein's theory of relativity was fundamentally flawed
  - B. Newton's laws of motion do not apply in high-mass environments
  - C. Einstein's prediction of gravity waves is correct
  - D. The collision of two black holes resulted in the detection of interstellar dark matter
- 31) Which country considers putting its nuclear forces on trigger alert this spring?
- A. Pakistan
  - B. China
  - C. India
  - D. Israel
  - E. France

32) Which of the following is NOT a reason cited in the discourse mentioned in the previous question?

- A. Concerns about US Missile Defense
- B. Survivability of the second strike deterrent capability
- C. Concerns about increasingly precise conventional arms held by the US and others
- D. Adherence to “mutual vulnerability” agreed upon by the United States and this country

33) What evidence did the Israeli defense minister give that Arab states were preparing to develop nuclear weapons in response to the Iran nuclear deal?

- A. Back channel discussions with the Saudis
- B. Satellite photos of new reactors being built
- C. Emails and purchase receipts for dual use goods
- D. All of the Above
- E. There was no evidence given

34) What did US defense secretary Ash Carter say about the UK’s nuclear force this spring?

- A. It allows the UK to “punch above its weight”
- B. It is a model for an effective small scale deterrent force
- C. It is an important part of the “special relationship” between the US and UK
- D. A and C
- E. B and C

#### **D. Nuclear weapon delivery methods**

35) Which of the following was not a leg of the US Triad during the Cold War?

- A. SLBM on SSBNs
- B. ICBM in silos
- C. Cruise Missiles on mobile launchers
- D. Long Range Bombers

36) What is the main advantage of SLBMs in their strategic role in the Triad?

- A. They are protected from first strike attacks
- B. They are more accurate than other delivery systems
- C. They are cheaper to maintain than other delivery systems
- D. They are easier to develop than other delivery systems



- 37) The Chinese Silkworm cruise missile has a range of 180 miles. What does this range suggest?
- A. The Chinese have not succeeded of designing an accurate weapon with a longer range.
  - B. The Chinese perceive an enemy navy as a significant threat and this range is sufficient to destroy an enemy carrier group.
  - C. Designed after the Sino-Soviet Split, 180 miles is the distance between the silos in Altay, China and the Soviet Severnaya Satellite Station.
  - D. Chinese nuclear weapons are too heavy and limit the range of all Chinese missiles.
- 38) What is the primary difference between a hot and cold launch for a missile?
- A. A hot launch refers to procedures used to launch missiles in warm climates like Guam, whereas cold launches are used for Alaskan silos.
  - B. A hot launch occurs from a moving vehicle like an airplane or submarine, while a cold launch occurs from a stationary location like a silo.
  - C. A hot launch requires rocket engines to start within a silo, while a cold launch is initiated by a high-pressure ejection, and then activation of engines.
  - D. A hot launch is initiated by a high-pressure ejection, and then activation of engines, while a cold launch requires rocket engines to start within a silo.
- 39) Cruise missiles were developed by \_\_\_\_\_,  
and today are considered most effective against \_\_\_\_\_
- A. China, the United States
  - B. The United States, Russia
  - C. Russia, Russia
  - D. The United States, the United States
  - E. Russia, the United States
- 40) Which of the following is not one of the technologies that help cruise missiles fly accurately?
- A. GPS
  - B. Terminal Guidance
  - C. Terrain Contour Mapping
  - D. Active Remote Guidance
  - E. Miniaturized Computers

- 41) What is the primary difference between ballistic missiles and cruise missiles?
- A. Cruise missiles go longer distances
  - B. Ballistic missiles carry fuel and oxidizer on them while cruise missiles rely on oxidizer in the air
  - C. Ballistic missiles are now primarily liquid fueled, while cruise missiles are all solid fueled.
  - D. Cruise missiles can carry multiple warheads while ballistic missiles cannot.
- 42) Which of the following phases are exoatmospheric for ICBM? (**mark all correct answers**)
- A. Boost Phase
  - B. Midcourse phase
  - C. Terminal Phase
  - D. Post-boost phase
- 43) Which category missiles would be used to target a battlefield military target?
- A. Theater ballistic missiles
  - B. Strategic ballistic missiles
  - C. Tactical ballistic missiles

### **E. Nuclear Explosions**

- 44) A nuclear attack on a country would lift soot into the atmosphere, screening the sunlight and reducing surface temperatures on Earth. How long would it take for half of the soot to fall out of the atmosphere?
- A. 1 month
  - B. 1 year
  - C. 5 years
  - D. 10 years
- 45) Deep underground nuclear tests can be detected through the monitoring of:  
(**mark all correct answers**)
- A. The release of radioactive noble gases
  - B. Irregular seismic activity
  - C. The development of cracks in the Earth's surface
  - D. Deep underground nuclear tests cannot be detected
  - E. Detection of low frequency acoustic signals

46) In which of the following test environments did the United States discover the effects of the EMP (Electromagnetic Pulse) following a nuclear explosion?

- A. Explosions in space
- B. Explosions at high altitudes
- C. Underwater bursts
- D. Air and surface bursts

47) Which of the following statements are correct for a 100 kT explosion.

**(mark all correct answers)**

- A. Surface burst produces greater fallout than an airburst
- B. The fireball touches the ground unless HOB > 3000ft
- C. Seismic waves caused by the explosion can be detected even at large distances
- D. If tested at a sufficient depth, an underground nuclear weapon test can be carried out undetected
- E. For a fully contained (no venting) underground nuclear explosion, no radioactivity (except noble gases) is released

48) What is the expected change in global surface temperatures that would be produced if the weapons in the current strategic arsenals of the U.S and Russia were exploded?

- A. -9 to -7 C
- B. -3 to -4 C
- C. -2 to 0 C
- D. 0 to +2 C
- E. +3 to +4 C

49) The theft of Co-60 in Mexico caused international concern because

- A. Co-60 is a fertile material and can be used to breed fissile nuclides
- B. Co-60 is a NEM and can be used in nuclear weapons
- C. Co-60 could be used in a radiological weapon
- D. Co-60 is highly toxic and can be dispersed easily as a chemical weapon

- 50) Could a terrorist group construct a workable bomb using reactor-grade plutonium?
- A. No
  - B. Yes, but with difficulty
  - C. Yes, easily

**F. Terrorism and its characteristics**

51) According to Richardson, terrorists act with 3 immediate objectives (the “3 Rs”) in mind, what are they?

- A. Relevance, Renown, Reconciliation
- B. Righteousness, Rage, Redemption
- C. Revenge, Renown, Reaction
- D. Revenge, Retribution, Reaction

52) Which group of materials listed below all contain naturally radioactive isotopes that can cause a radiological false alarm in the portal monitors on the border?

- A. Bananas, hand soap, cell phones
- B. Glass, ceramics, fabric
- C. Hand soap, cell phones, glass
- D. Kitty litter, ceramics, bananas

53) In the movie, “Last Best Chance” the terrorist group justified usage of nuclear weapons against the West due to which of the following?

- A. U.S. forces stationed in the Middle East
- B. Demands made by senior leadership of the group
- C. Sum of all Muslims killed by Western troops
- D. Inspiration from U.S. bombing of Japan in WWII

54) Smuggling a nuclear device through a shipping container is often mentioned as a viable tactic for terrorist groups. What percentage of shipping containers are inspected carefully that enter the United States?

- A. 2%
- B. 6%
- C. 25%
- D. 60%

55) Which of the following is not one of the “lethal triple cocktail” of factors that Richardson argues leads to terrorism?

- A. Extreme poverty
- B. A disaffected individual
- C. A legitimizing ideology
- D. An enabling community

56) Which of the below is NOT one of the standard phases in the response to terrorism of a society without previous experience with terrorism?

- A. Polarization of politics
- B. Demonstration of resolve by adopting draconian responses that largely go unchallenged by the public
- C. Reasoned reflection on the nature of the threat and measured and efficient response
- D. Societal lack of concern regarding the seriousness of the threat

57) What type of nuclear weapon design would be easiest for a terrorist group to construct?

- A. Gun type
- B. Implosion
- C. Levitated-pit implosion
- D. Two-point hollow-pit implosion

58) Which of the following is NOT a defining characteristic of terrorism?

- A. The act must be violent or threaten violence
- B. The violence must be against civilians
- C. The individual victims must be randomly chosen
- D. The violence must be deliberate
- E. The violence must have a political purpose

59) In the award-winning docudrama “Last Best Chance” shown in class, although the border guard scanned the cargo with a radiation detector, he failed to detect the nuclear bomb. Why?

- A. The bomb was likely shielded by a material like lead
- B. The detector was not powerful enough to detect the bomb
- C. The border guard did not know how to properly use the device
- D. Fissile material in warheads are not detectible by portable radiation detectors

60) Which of the following is *not* a reason that an implosion-type bomb would present more technical challenges than other types?

- A. Difficulty in acquiring LEU
- B. Difficulty in designing high explosive lenses
- C. Difficulty in machining and assembling precision parts
- D. Difficulty in triggering the implosion

61) Which of the following are *not* one of the “Three No’s” that Graham formulates in his doctrine in order to deny terrorists access to nuclear weapons or materials?

- A. No loose nukes
- B. No new nascent nukes
- C. No new nuclear material
- D. No new nuclear weapon states

62) What is the most pressing action required to prevent terrorists from going nuclear?

- A. Ensuring that other countries do not directly sell bombs to any terrorist organizations or non-state actors
- B. Implementing the “Star Wars” strategic defense initiative that Reagan put into place in the 80s
- C. Increasing security on HEU stockpiles in places like Russia and Pakistan that are most vulnerable to theft so that they cannot build a bomb
- D. Improving the protection of nuclear weapons in the United States from possible theft

**G. Nuclear materials**

63) Identify the two most common fissile isotopes used for making fission weapons

- A. U-235 and Pu-239
- B. Th-232 and Pu-239
- C. U-238 and Pu-239
- D. U-238 and Pu-240
- E. U-235 and Pu-238

**Questions 64 - 66 are related to the picture and description below**

In 1994 the briefcase pictured to the left was confiscated at the Munich airport. Inside, security personnel found 560g of plutonium and uranium oxide, as well as 210g of lithium metal which contained 89.4% Lithium-6.



64) Without any additional information which of the following answer describes best which weapons would **not** be possible to make from the material in the briefcase?

- A. A plutonium nuclear fission weapon
- B. A uranium nuclear fission weapon
- C. A thermonuclear weapon
- D. Both, plutonium and uranium nuclear fission weapons
- E. All three, a plutonium nuclear fission weapon, uranium nuclear fission weapon, and a thermonuclear weapon

65) Now one learns that the plutonium was “low burn-up” plutonium whereas the uranium had a low level of U-235 enrichment. Which of the following weapons designs would be the easiest to make starting from the smuggled nuclear-explosive material?

- A. An implosion type plutonium nuclear fission weapon
- B. An implosion type uranium nuclear fission weapon
- C. A gun type plutonium nuclear fission weapon
- D. A gun type uranium nuclear fission weapon
- E. A thermonuclear weapon

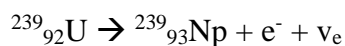
66) What would be the **most likely** purpose of the lithium metal in a nuclear weapon?

- A. The Li-6 used as an initiator of an implosion type nuclear fission weapon
- B. The lithium metal used as a reflector for an implosion type nuclear weapon to reduce the number of neutrons that escape a configuration of fissile material
- C. The Li-6 combined with deuterium used as the fusion packet inside a thermonuclear weapon
- D. The lithium metal used as the breeder of triton in a gun type nuclear fission weapon
- E. The Li-6 used as an impurity in the hollow shell (“pit”) of a thermonuclear weapon

67) Which would influence the amount of nuclear explosive material needed to have a critical mass? (**mark all correct answers**)

- A. Density of the NEM
- B. The addition of a neutron initiator
- C. Purity of nuclear explosive isotope in the NEM
- D. Presence of a neutron reflector surrounding the NEM
- E. Geometry of the NEM

68) What does the following process represent:



- A. Photon Torpedo
- B. Neutron capture
- C. Alpha-decay
- D. Beta-decay
- E. Gamma-decay



69) What neutron multiplication factor ( $R$ ) is required for the nuclear material configuration to be considered supercritical?

- A.  $R < 0$
- B.  $R = 0$
- C.  $0 < R < 1$
- D.  $R = 1$
- E.  $R > 1$

70) What is the main reason why reactor-grade plutonium (RGP) is *not* preferred for use in nuclear weapons?

- A. It is too expensive to produce
- B. Its irradiation period is too short causing high concentrations of unwanted Pu isotopes
- C. Its irradiation period is too long causing high concentrations of unwanted Pu isotopes
- D. It is impossible to make a nuclear weapon with RGP

71-73) **Definitions.** The following table will be used for questions 71-73. The table lists 3 terms that need to be defined. Each row in the table corresponds to one question, 1-3. Listed below the table are possible definitions to the terms listed in the table. On your answer sheet bubble for each question the matching answer key from the possible definitions list (A-E). **[2 points each]**

|   |
|---|
| _____ 71) Weapons-useable uranium                                   |
| _____ 72) <i>Preferred</i> enrichment of uranium for use in weapons |
| _____ 73) Weapons-grade plutonium                                   |

- A. Enriched to 20% U-235
- B. Enriched to 80% U-235
- C. Enriched to 90% U-235
- D. Enriched to 80% Pu-239
- E. Enriched to 93% Pu-239

**H. Short Essay Question – 22 points of 320 (Limit Answer to one page on the next sheet)**

74) A group of rogue nuclear physicists have threatened to detonate a nuclear weapon on US soil if their demands for increased funding are not met. Limited intelligence suggests that they are planning on generating nuclear-explosive material covertly, perhaps using an enrichment technology of their own design. The physicists have no military training, so it is very unlikely that they will be able to steal a weapon or weapons-grade material. The physicists plan on driving their nuclear weapon in a truck from their secret base to their target location. As a domestic intelligence agency, **describe the proliferation strategy the rouge physicists are attempting to pursue and your agency's response**, making sure to address the following questions.

- What common nuclear-explosive material requires enrichment to reach weapons grade?
- What fission weapon design is likely?
- The secret base is undetectable by spy satellites and does not draw on large amounts of electricity. Given the background of the terrorists, what enrichment technology seems likely?
- What strategy could your intelligence agency employ to catch the terrorists *before* they have assembled the bomb?
- What strategy could your intelligence agency employ to catch the terrorists *after* the weapon has been moved away from the secret base?

Written Answer to question 74 – limit hand written answer to space on this page. Note it is important to write your name and writing lab – this page will be separated from the exam for grading:

Name:

Your Writing Lab:

**Check to make sure you bubbled in all your answers.  
Did you bubble in your name, exam version and network-ID?**