



UNIVERSITY OF BRITISH
COLUMBIA
Faculty of Science
Science One



**NSERC
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promo
Science

Michael Smith National Science Challenge 2012

Tuesday, February 28th, 2012

9-10 Pacific, 10-11 Mountain, 11-12 Central, 12-1 Eastern, 1-2 Atlantic, 1:30-2:30
Newfoundland

PLEASE PRINT DOUBLE-SIDED (BLACK AND WHITE OK)

Instructions

1. Do not open this examination booklet until you are told to do so.
2. Be certain that you understand all of the instructions. If not, ask your teacher.
3. Do not ask your teacher for any help with the content of the examination.
4. This examination is closed-book. No notes of any kind (printed or electronic) are allowed.
5. You may use a calculator (may be a graphing calculator) and a ruler.
6. Write your answers in this exam booklet and hand it back to your teacher at the end.
7. This exam booklet consists of 5 questions on 8 pages; including this page of instructions. Check to make sure you have all the pages.
8. Print your name and other information clearly. Only those who do so can be counted as official contestants.
9. When your teacher instructs you to begin, you will have **60 minutes** to finish the examination.

Scoring

Full marks will be given to a student who demonstrates clear understanding of the science required by the question.

Partial marks will be given for partial understanding. There are no penalties for incorrect answers. The questions are not of equal difficulty. Remember we are challenging the best science students in Canada; it is possible that even the best papers may not achieve an overall score of 80%. This is meant to be tough!

Teachers

Please mail* the following **2 items** to Michael Smith Challenge, Department of Physics & Astronomy, 6224 Agricultural Road, UBC, Vancouver, BC, V6T 1Z1 before the end of **Tuesday, February 28th, 2012**:

1. Students' exam booklets
2. A cheque payable to University of British Columbia, for \$5.00 per script returned (if paying by cheque) **OR** a printed receipt of your payment (if paid by credit card).

* Canada Post regular mail; express/couriers *not* necessary.

Contest Named in Honour of Dr. Michael Smith (1932-2000)

UBC's 1993 Nobel Prize Winner

Examination Committee

Zendai Kashino, Andrzej Kotlicki, Theresa Liao, Chris Waltham, UBC Dept. of Physics & Astronomy
Celeste Leander, UBC Department of Botany
Tamara Kunz, UBC Department of Chemistry

Translator

Louis Deslauriers, UBC Physics and Astronomy

TEAR OFF FRONT PAGE

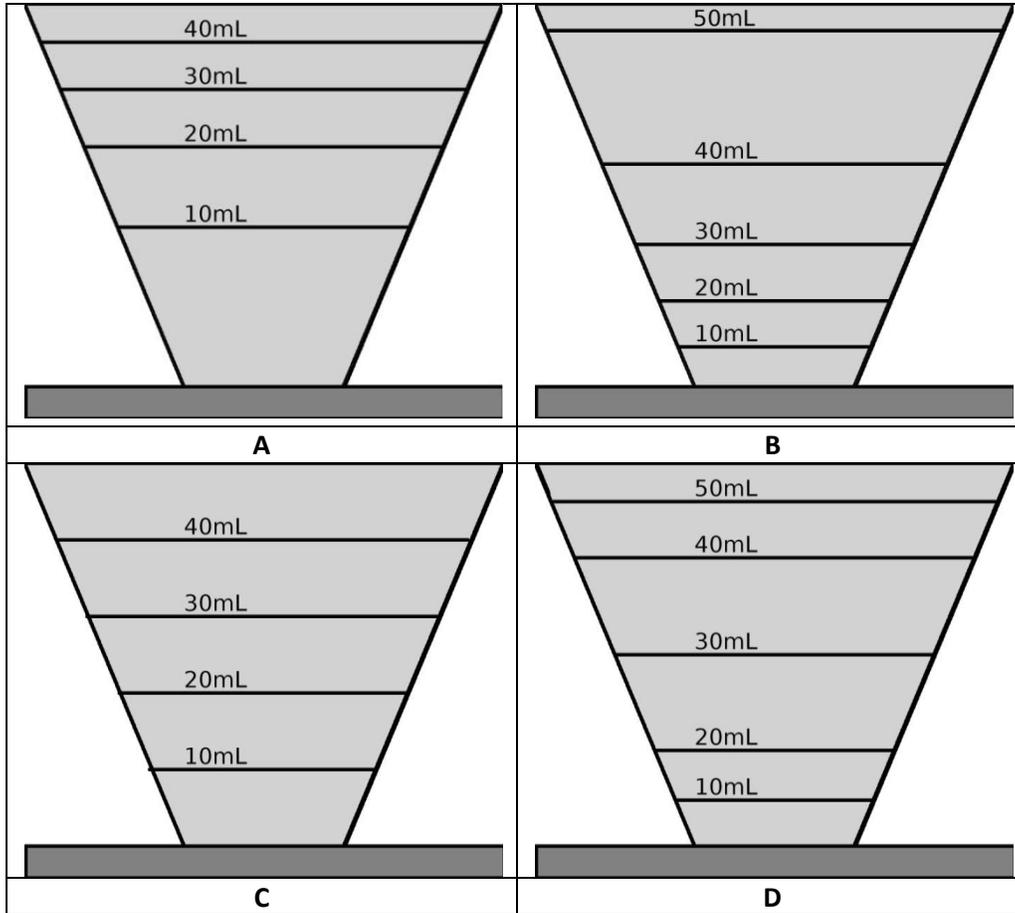
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NAME (PRINT) _____

SCHOOL _____

| 1 | 2 | 3 | 4 | 5 | TOTAL |
|-----------|------------|------------|------------|-----------|------------|
| /7 | /10 | /15 | /10 | /6 | /48 |

1. Consider the measuring cups below:

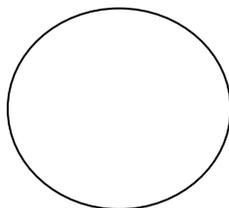


Which measuring cup appears to be the most trustworthy? Explain your choice in no more than 60 words. (7 marks)

2. Some scientists have pointed out that it may be better for the environment for a person to commute in a car than to cycle to and from work, particularly if that person is an exclusive carnivore. How can this possibly be, given that a car is about 100 times heavier than a bicycle? (10 marks)

3. An atom is made up of fundamental pieces called protons, neutrons and electrons. Protons are positively charged, neutrons have no charge and electrons are negatively charged.

A. In the diagram of a spherical atom below, label where you would find the protons, neutrons and electrons (3 marks):



B. The mass of an element is determined from the sum of certain particles within an atom. If given the symbol ${}^1_6\text{C}$ for the neutral element carbon, how many neutrons are there? How do you know? (2 marks)

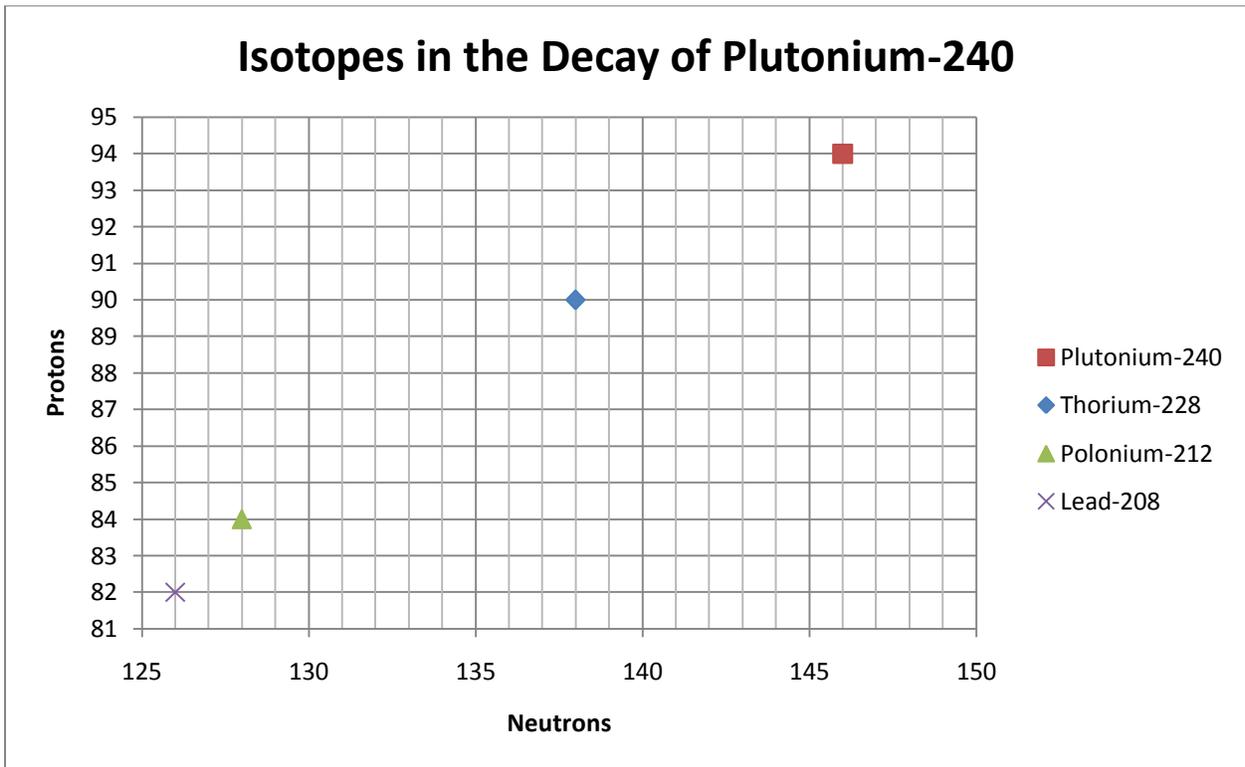
C. Carbon dating is a technique used to determine the age of very old artefacts. It is performed with a very rare isotope of carbon known as carbon-14 (${}^{14}_6\text{C}$). How is this atom of carbon different from the more common atom of carbon known as carbon-12 (${}^{12}_6\text{C}$)? (2 marks)

D. Natural carbon (12.011 amu) has 2 common isotopes known as carbon-12 (12.0 amu), and carbon-13 (13.003 amu). The given mass of an element is the weighted average of its isotopes, what are the relative percentages (%) of each isotope in carbon? (3 marks)

- E. One of the radioactive isotopes released when the Fukushima reactor failed was plutonium-240. This radioactive isotope undergoes a series of alpha and beta decays to become lead-208. The series includes stages with thorium-228 and polonium-212.

Suggest a series of alpha and beta decays that could make up this process by plotting the isotopes and the path between them on the graph below. The names of the intermediate species are not needed here.

Note: remember that alpha decay is the release of an alpha particle (helium-4) and beta decay is the transmutation of a neutron into a proton. (5 marks)



4. The following paragraph explains some of the science behind the Touhoku Earthquake that shook Japan on March 11, 2011. Complete the paragraph by filling in the blanks with the words provided. (10 marks)

Earthquakes happen when the earth's _____ suddenly moves due to stored up _____ energy being released as _____ energy; the greater the movement of the crust, the greater the _____ of the earthquake. The earthquake in Japan had its _____ off the east coast of Japan. The earthquake displaced a large amount of _____ and resulted in a _____, a wave that started off with low _____ and long _____ but became tall by the time it reached the shore. The power of it was so great that it set off warnings all around the Pacific Rim. Even after the earthquake, smaller tremors called _____ continued to occur, causing worry about the damaged nuclear power plants.

| | | | | |
|------------------|-----------|-----------|-----------|------------|
| magnitude | damage | movement | moving | wavelength |
| micro vibrations | crust | frequency | amplitude | S-wave |
| mantle | potential | core | zero | dirt |
| P-wave | water | epicentre | air | elastic |
| aftershocks | tsunami | kinetic | | |

5. A list of household appliances is given below with their power ratings. Given a house circuit with a circuit breaker rated for 16A, what is the maximum number of appliances you can run on this circuit? Which appliances are they? Assume a house circuit has a voltage of 120V. Show your calculations. (6 marks)

| Appliance | Power rating(watts) |
|---------------------------------------|---------------------------|
| Bank of incandescent lights(10 bulbs) | 1000 |
| Refrigerator | 70 (average)*, 480 (peak) |
| Vacuum | 600 |
| Microwave | 720 |
| Toaster | 1200 |

*This average assumes 2 hours of usage per week