



UNIVERSITY OF BRITISH
COLUMBIA
Faculty of Science



**NSERC
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promo
Science

Michael Smith National Science Challenge 2015

Tuesday, February 24th, 2015

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 to Students

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 (graphing or scientific) and a ruler.
6. No computers, tablets, cellphones, or internet-capable devices are allowed.
7. Write your answers in this exam booklet and hand it back to your teacher at the end.
8. This exam booklet consists of 4 questions on 11 pages, including this page of instruction.
9. Print your name and other information clearly. Only those who do so can be counted as contestants.
10. When your teacher instructs you to begin, you will have **60 minutes** to finish the examination.

Scoring

Full marks will be given those who demonstrates clear understanding of the science.
Partial marks will be given for partial understanding. There are no penalties for incorrect answers.
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!

Instructions to Teachers

Please mail* the following **two items** to Michael Smith Challenge, Department of Physics & Astronomy, 6224 Agricultural Road, UBC, Vancouver, BC, V6T 1Z1 by the end of **Tuesday, February 24th, 2015**:

1. Students' exam booklets**
2. A cheque payable to University of British Columbia, for \$6.00 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.

****NEW**: You may instead scan all the exam booklets and email one pdf file (150dpi, grayscale, <15MB) to mschall@phas.ubc.ca. Please ensure students' writing is readable in the pdf file. Do not include this front page. You will receive a confirmation email within two days of submission. Please keep all the exam booklets until you receive this confirmation email.

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

UBC's 1993 Nobel Prize Winner

Examination Committee

Emma Ostreicher, Theresa Liao, and Chris Waltham, UBC Department of Physics & Astronomy
Susan Vickers, UBC Department of Chemistry; Celeste Leander, UBC Department of Botany

Translator

Nikita Bernier, UBC Department of Physics & Astronomy

TEAR OFF FRONT PAGE

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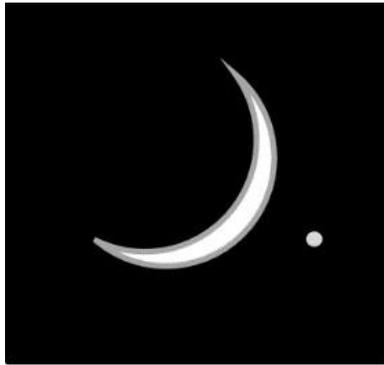
NAME (PRINT) _____ SCHOOL (PRINT) _____

Q1	Q2	Q3	Q4	Total
/10	/20	/30	/20	/80

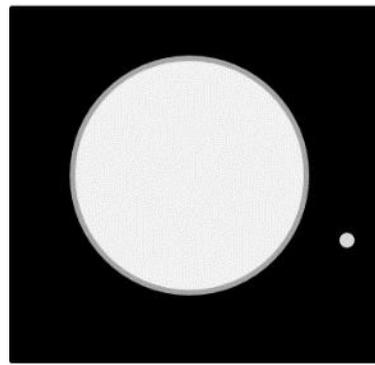
1. We live in exciting times for solar system astronomy; Curiosity is wandering over Mars, New Horizons is reaching Pluto, and Philae has landed on a comet. Another comet (Lovejoy) is currently visible in the night sky.

a) Consider the pictures below of the Moon and a planet, as viewed from Earth. In each case, which planet could this be? Write all possible answers in the boxes provided.

A.



B.

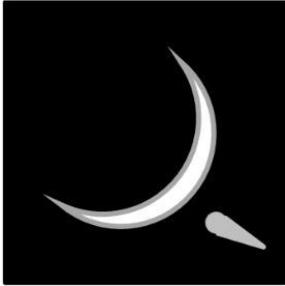


Naked-eye planets in order of distance from the Sun:
I. Mercury II. Venus III. Mars IV. Jupiter V. Saturn

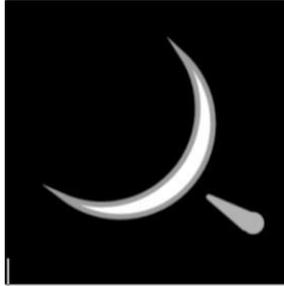
Briefly explain your reasoning.

b) Consider the pictures below of the Moon and a comet, as viewed from Earth. Circle the letter(s) by the picture(s) that are possible.

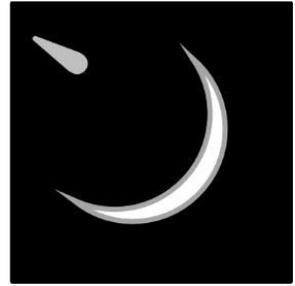
A.



B.



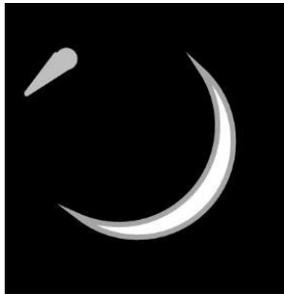
C.



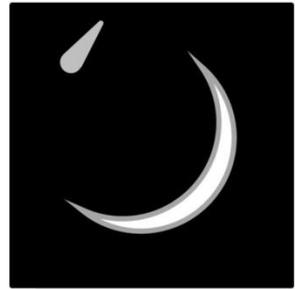
D.



E.



F.



Briefly explain your reasoning.

2. This year, 2015, is the International Year of Light. Here are some questions regarding the nature of light.

a) The two pictures below were each taken with the same automatic single-exposure digital camera and with the same interior lighting. The pictures were taken from the same position facing a window, one hour apart from each other, in early January. What observations can you make? What explanations can you give? Check all boxes next to correct statements.

7am



8am



- | | |
|--------------------------|--|
| <input type="checkbox"/> | Bright light on one side of the glass stops weak light on the other side of the glass from getting through. |
| <input type="checkbox"/> | It is difficult to see outside from a lit room when it is dark out. |
| <input type="checkbox"/> | The window behaves like a mirror when it is lit predominantly from the observer side. |
| <input type="checkbox"/> | The glass is a one-way mirror that only responds when there is less illumination behind the mirror side. |
| <input type="checkbox"/> | The glass reflects a small fraction of the incident light which is only visible if the exterior illumination is low. |
| <input type="checkbox"/> | The glass refracts a small fraction of the incident light which creates an image in the glass if the exterior illumination is low. |
| <input type="checkbox"/> | Multiple refraction of light in the glass causes an image to form against the dimly illuminated exterior. |
| <input type="checkbox"/> | At 8am, the rising sun has warmed the glass, allowing light to pass through. |
| <input type="checkbox"/> | The automatic focus camera focused on the glass in the first picture because it was dark outside. |
| <input type="checkbox"/> | The photographer does not have steady hands. |
| <input type="checkbox"/> | There are multiple images in the 7am picture because the window is (assumedly) double glazed. |

b) The first picture below is taken using visible light and the second (of the same person) is taken using thermal infrared. Infrared radiation is emitted by any body with a non-zero temperature (with more emission from warmer objects). What can you deduce about visible light and infrared light? Check all the boxes next to correct statements.



Visible Light



Thermal Infrared

- | | |
|--------------------------|---|
| <input type="checkbox"/> | Spectacle lenses absorb infrared light. |
| <input type="checkbox"/> | Spectacle lenses transmit infrared light. |
| <input type="checkbox"/> | Spectacle lenses absorb visible light. |
| <input type="checkbox"/> | Spectacle lenses transmit visible light. |
| <input type="checkbox"/> | Spectacle lenses emit infrared light. |
| <input type="checkbox"/> | Spectacle lenses emit visible light. |
| <input type="checkbox"/> | The order of temperature from highest to lowest is: skin, lens, clothing. |
| <input type="checkbox"/> | The order of temperature from highest to lowest is: skin, clothing, lens. |
| <input type="checkbox"/> | The order of temperature from highest to lowest is: clothing, skin, lens. |

3. As the Earth's climate warms, we are increasingly concerned with the effects caused by large amounts of material changing its state: e.g. ice melting, water condensing and evaporating, gas dissolving and coming out of solution, etc.

a) For each of the following situations, how many states of matter are present (not counting the surrounding air)? Circle ONE number.

I) Ice cubes floating in a glass of water

0 1 2 3 4

II) Aqueous salt solution at room temperature containing 3% salt by weight.

0 1 2 3 4

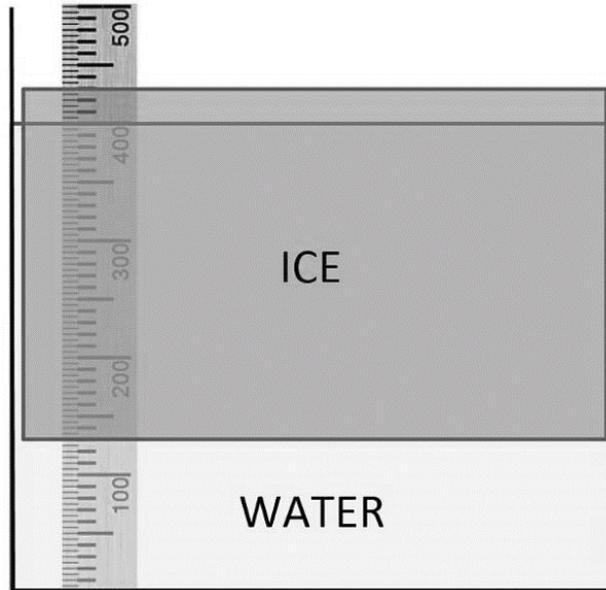
III) The contents of an unopened bottle of soda water.

0 1 2 3 4

b) What is inside the bubbles seen in water that has been continuously boiling for 5 minutes?

c) Ice floats on water. Using your knowledge of the structure of liquids, solids and gases, explain briefly why this is called an "anomaly".

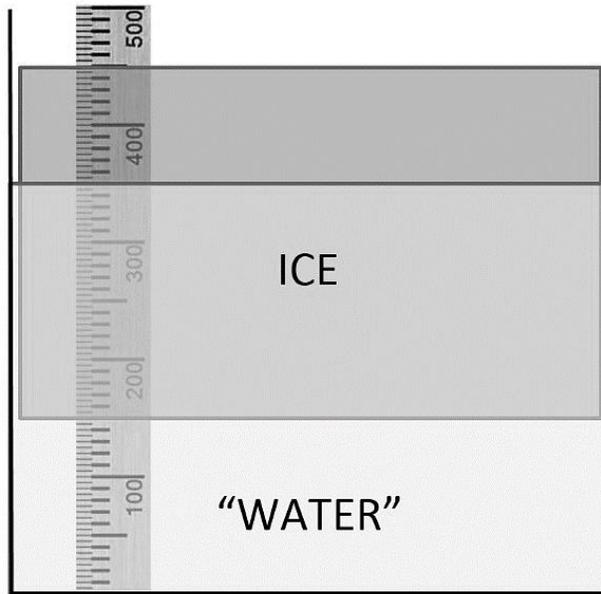
d) The figure below shows pure ice floating in pure water in a glass vessel. The measuring stick is marked in mm. Given that the density of pure water is 1000 kg/m^3 , deduce the density of the ice. No prior knowledge of density calculations is needed for this question.



Show your reasoning:

e) Assuming the gap between the vessel and the ice is very small, what will the water level be if the ice melts? Why?

f) Arctic ice is very pure water but when it melts it does so into salty water. To figure out what will happen to the sea level, consider an exaggerated case below where the ice is pure but the water is very dense. Assuming the gap between the vessel and the ice is very small, what will the water level be if the ice melts? Use the ice density you found in d).

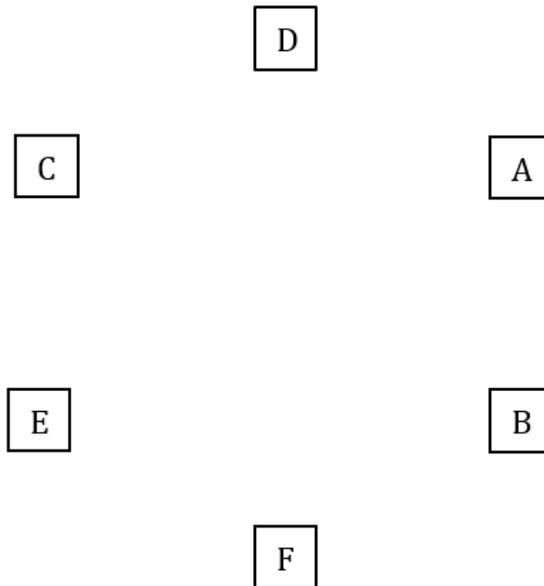


Show your reasoning:

4. In order to monitor the health of the biosphere and how it is coping with human impacts, it is important to understand how all the elements of the natural world interact with each other. Consider the following example. In 2000, a group of biologists determined the biomass of each species present in an ecosystem. This table displays their results:

Species	Biomass (kg)
A	1200
B	300
C	200,000
D	10,000
E	15,000
F	800

a) Construct a food web using the skeleton provided by drawing arrows between the species to indicate the flow of energy through the ecosystem. Assume each species will only eat another species on a trophic level one below theirs.



b) The species recorded in the ecosystem were: mice, foxes, lizards, butterflies, cougars, and apple trees. What could each species in the table above possibly have been?

A:

B:

C:

D:

E:

F:

c) Data were collected again in the same area in 2010.

Species	Biomass (kg)
A	1200
B	200
C	250,000
D	11,000
E	8000
F	600

What could have caused the change in species E? Give one natural and one human disturbance.

Natural Cause:

Human Cause:

What did you notice about the differences between the 2000 and 2010 data?