



a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

Faculty of Science

PHYSICS UBC DEPARTMENT OF
ASTRONOMY



Défi Scientifique Michael Smith Science Challenge

Wednesday, February 13th 2019

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 contest 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 contest.
4. This contest 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 other wireless devices are allowed.
7. Write your answers in this booklet and hand it back to your teacher at the end.
8. This booklet consists of 4 questions on 8 pages, including this page of instruction.
9. Print your name and other information clearly. Only those who do so can be counted as official contestants.
10. When your teacher instructs you to begin, you will have **60 minutes** to finish the contest.

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. We are challenging the strongest science students in Canada; it is possible that highest overall score will be less than 80%. This is meant to be tough!

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 **Wednesday, February 13th, 2019**:

1. Students' contest booklets
2. A cheque payable to "UBC Physics & Astronomy", for \$6.00 per script returned (if paying by cheque) **OR** a printed receipt of your payment (if paid by credit card).

Please do not send by email.

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

UBC's 1993 Nobel Prize Winner

Contest Committee

Nikita Bernier (translator), Shannon MacFarland, Theresa Liao, and Chris Waltham, UBC Department of Physics & Astronomy

TEAR OFF THIS PAGE

NAME _____ SCHOOL _____

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

1. You are designing a light rail transit system in a new, as yet unbuilt, city. The city is to be built on bare but hilly terrain shown on the contour map below. Your task is to design the shortest track between two planned suburbs, marked with circles A and B, with a grade no larger than 2% (i.e. the elevation must not rise or fall more than 20 metres per km). The track is to be built on the surface; you are not allowed to build bridges, cuttings or tunnels. Draw a line to show where the track should be built.

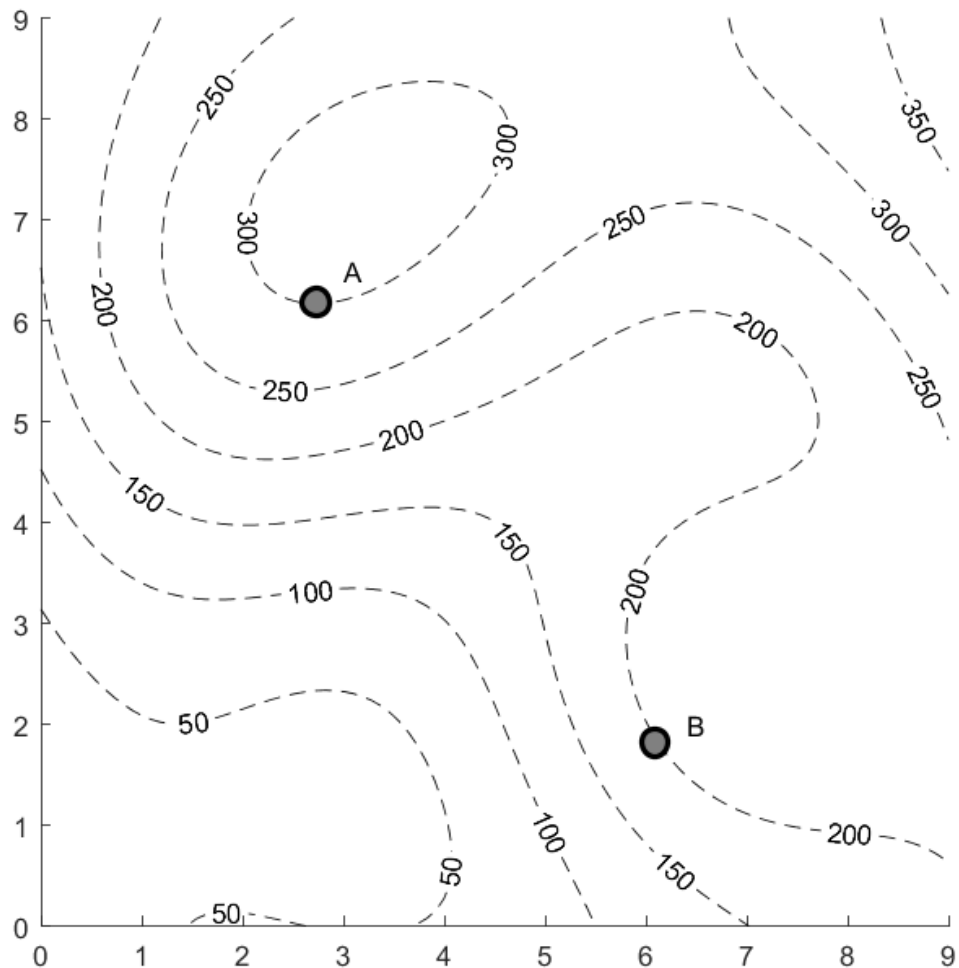


Figure 1. Contour map of site of planned city. The axes are marked in km, the contours in metres.

2. In late 2018 the British Columbia (BC) government announced that all cars in the province must be solely electric-powered by the year 2040. If we are to avoid powering these cars with electricity generated by burning fossil fuels, we will need new hydro-electric facilities and windfarms.

(a) The population of BC is five million and its residents own about three million cars. Assume each car is driven 20,000 km per year, with an average fuel economy of 10 L/100 km, and that the energy content of gasoline is 36 MJ/L. How much extra power will the province need to produce to run all these cars solely on electricity?

Note: There are inefficiencies (energy losses) in both running gasoline engines and powering electric motors, so assume for the purposes of comparison that these inefficiencies are the same.

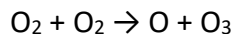
Give your answer in the most appropriate units (i.e. W, kW, MW, GW etc.)

(b) Comment on the magnitude of your answer to (a).

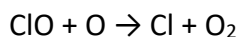
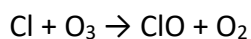
A large, empty rectangular box with a thin black border, intended for the student to write their comment on the magnitude of their answer to part (a).

3. The 1987 Montreal Protocol called for all developing countries to stop production of ozone-destroying chlorofluorocarbons (CFCs) by 2005. Most industrialized nations had stopped production by 1995. However, there is evidence that CFC production is now increasing.

Ozone (O_3) and atomic oxygen (O) are produced in the upper-atmosphere by the interaction of sunlight with ordinary molecular oxygen (O_2), forming the "ozone layer":



If CFCs get into the upper-atmosphere, sunlight splits the molecules to form atomic chlorine, Cl . Then this pair of chemical reactions happens, resulting in the breakdown of ozone back into ordinary molecular oxygen:

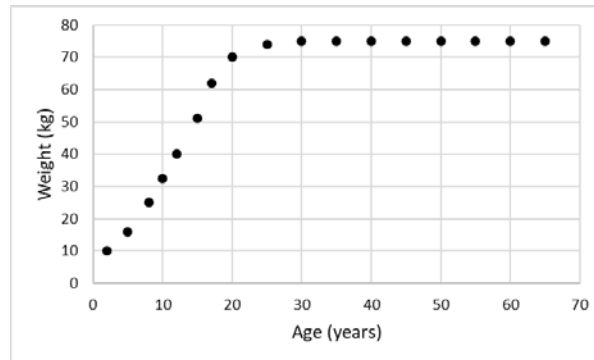


- (a) Why is even a tiny amount of atomic chlorine so damaging to the ozone layer?

- (b) Why is the integrity of the ozone layer so important?

4. Consider these questions about food and nutrition. For (a)-(c) we are looking for statements based on general principles that compare the mass excreted to the mass ingested. In each case, briefly state which principle you are considering.

Here is a plot of how the weight of person "A" developed with age:



- a) Health Canada recommends that healthy adults ingest mass X of sodium per day. What can you say about the mass of sodium that person "A" at age 40 should excrete per day? Why?

- b) Health Canada recommends that healthy teenagers ingest mass Y of calcium per day. What can you say about the mass of calcium that person "A" at age 15 should excrete per day? Why?

- c) Health Canada recommends that healthy adults ingest mass Z of carbohydrates per day. What can you say about the mass of carbohydrates that person "A" at age 40 should excrete per day? Why?

d) A five-year study of a novel food X by experts at University A concludes that X is perfectly safe. At the same time, another five-year study of X by experts at University B concludes that X is dangerous and should not be marketed. Assuming that the two panels of experts are equally distinguished, and you want to know whether you can eat X safely and regularly, what questions should you ask about these studies?

1.	
2.	
3.	