UNIVERSITY OF
BRITISH COLUMBIA
Faculty of Science

NSERC
CRSNG

promo Science

Michael Smith National Science Challenge 2005

Friday, April 8th, 2005

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

Instructions

1. Do not open the exam booklet until you are told to do so.
2. Be certain that you understand all of the instructions. If you are unsure about something, ask your supervisor.
3. This exam is closed-book. No notes of any kind (printed or electronic) are allowed.
4. You may use a calculator (may be a graphing calculator) and a ruler.
5. Write your answers in this exam booklet and hand it back to your teacher at the end.
6. This exam booklet consists of 12 questions on 8 pages; including this page of instructions and a data sheet. Check to make sure you have all the pages.
7. Print your name and other information clearly. Only those who do so can be counted as official contestants.
8. Do rough work on the back of the paper.
9. When your teacher instructs you to begin, you will have **60 minutes** to finish the exam.

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 courier the following **3 items** to Prof. Chris Waltham, Department of Physics & Astronomy, 6224 Agricultural Road, UBC, Vancouver, BC, V6T1Z1 before the end of **Friday, April 8, 2005**:

1. the completed student registration form(s)
2. students' exam booklets
3. a cheque payable to University of British Columbia, for $8.00 per answer sheet returned.

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

UBC's 1993 Nobel Prize Winner

Examination Committee

Chris Waltham, UBC Department of Physics and Astronomy
Andrzej Kotlicki, UBC Department of Physics and Astronomy
Jason Chow, UBC Department of Physics and Astronomy
Tony Griffiths, UBC Department of Botany
Gordon Bates, UBC Department of Chemistry
Stuart Sutherland, UBC Department of Earth and Ocean Sciences

English-to-French Translator

Marie-Pierre Milette, UBC Department of Physics and Astronomy
Tony Teke

PLEASE TEAR OFF THIS FRONT PAGE

Data Sheet
Fiche de données

Relative Atomic Masses (1985 IUPAC)
*For the radioactive elements the atomic mass of an important isotope is given

Masses Atomiques Relatives (UICPA, 1985)
*Dans le cas des éléments radioactifs, la masse atomique fournie est celle d'un isotope important

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.008																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.07	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.905	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.2	83 Bi 208.980	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.03	89 Ac 227.03	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs	109 Mt									

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu
90 Th 232.038	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

	Symbol / Symbole	Value / Quantité numérique	
Atomic mass unit	amu	1.66054×10^{-27} kg	Unité de masse atomique
Avogadro's number	N	6.02214×10^{23} mol^{-1}	Nombre d'Avogadro
Bohr radius	a_0	5.292×10^{-11} m	Rayon de Bohr
Boltzmann constant	k	1.38066×10^{-23} J K^{-1}	Constante de Boltzmann
Charge of an electron	e	1.60218×10^{-19} C	Charge d'un électron
Dissociation constant (H_2O)	K_w	10^{-14} (25 °C)	Constante de dissociation de l'eau (H_2O)
Faraday's constant	F	96 485 C mol^{-1}	Constante de Faraday
Gas constant	R	8.31451 J K^{-1} mol^{-1}	Constante des gaz
		0.08206 L atm K^{-1} mol^{-1}	
Mass of an electron	m_e	9.10939×10^{-31} kg	Masse d'un électron
		5.48580×10^{-4} amu	
Mass of a neutron	m_n	1.67493×10^{-27} kg	Masse d'un neutron
		1.00866 amu	
Mass of a proton	m_p	1.67262×10^{-27} kg	Masse d'un proton
		1.00728 amu	
Planck's constant	h	6.62608×10^{-34} J s	Constante de Planck
Speed of light	c	2.997925×10^{8} m s^{-1}	Vitesse de la lumière

1 Å	=	1×10^{-8} cm
1 eV	=	1.60219×10^{-19} J
1 cal	=	4.184 J
1 atm	=	101.325 kPa
1 bar	=	1×10^{5} Pa

PLEASE TEAR OFF THIS DATA SHEET

NAME (PRINT): ____

SCHOOOL: ____

GRADE: _______________________________ PROVINCE: __________________________

Questions

1. A computer is described as “3 GHz”. In 10 words or less, describe what “3 GHz” means, and what it refers to in this case.

3×10^9 CPU cycles per second;
CPU = Central Processing Unit, or “processor”, (“speed of computer”).

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2. Your family’s new car has a highway fuel consumption of 4.7 litres/100km. The American brochure for the same car says this is 50 miles per US gallon. Your American friend’s car has a fuel economy of 25 miles per US gallon on the highway – how many litres will your friend’s car consume per 100km?

9.4L/100km

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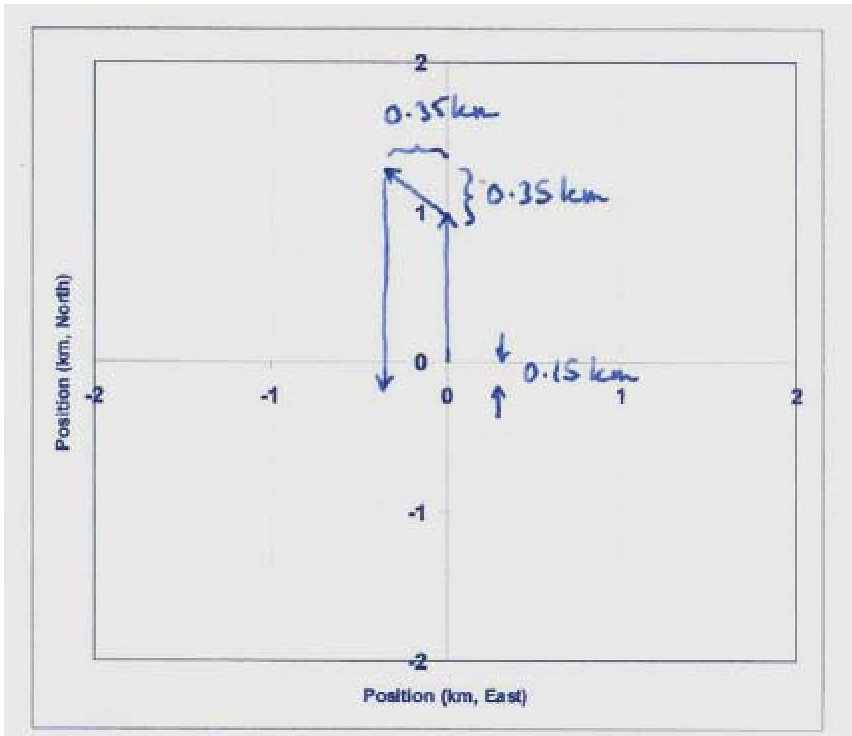
3. Draw a simple diagram to show what happens during a lunar eclipse.

S = Sun, E = Earth, M = Moon

NAME (PRINT): ____

4. You are lost in the woods with nothing to guide you but a compass. You estimate your walking speed is about 6 km/h. You walk North for 10 minutes, then turn 45 degrees to the left and walk for another 5 minutes. Then you decide to walk South for 15 minutes. Draw your track on the blank map below, starting in the middle.



How far are you now from your starting point? **0.38** km

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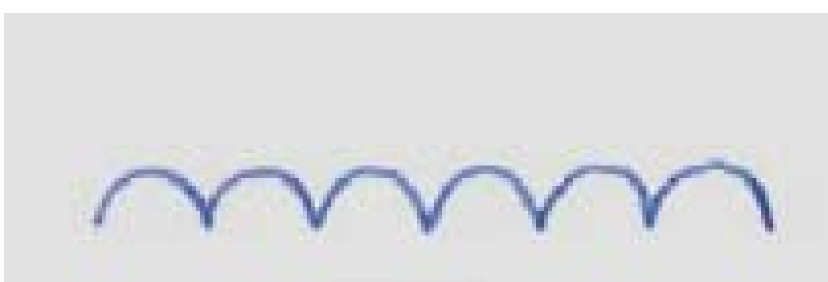
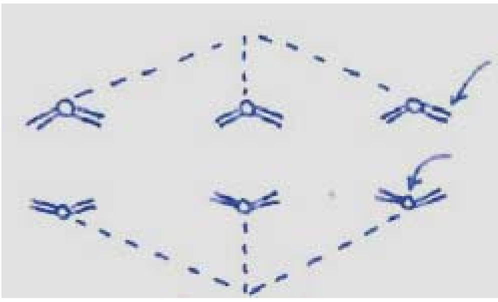
5. You attach a tiny bright light to the tire of your bicycle very close to where the rubber touches the road. Your friend takes a time exposure photograph of you cycling past from right to left, in the dark, and all that appears on the photo is a long streak from the light. Draw the shape of the streak:



NAME (PRINT): ____

6. Draw anaphase 1 of meiosis in a diploid cell where 2n = 6. Show all chromosomes or chromatids as appropriate. Let a line represent a chromosome or a chromatid.



Chromatids

Centromeres pulled apart

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7. Yeast cells reproduce by splitting into two cells once every thirty minutes. Assuming you start with one yeast cell, devise a formula relating the number of yeast cells (n) in a culture and time in hours (t).

$$\mathbf{2^{(2t/hours)}}$$

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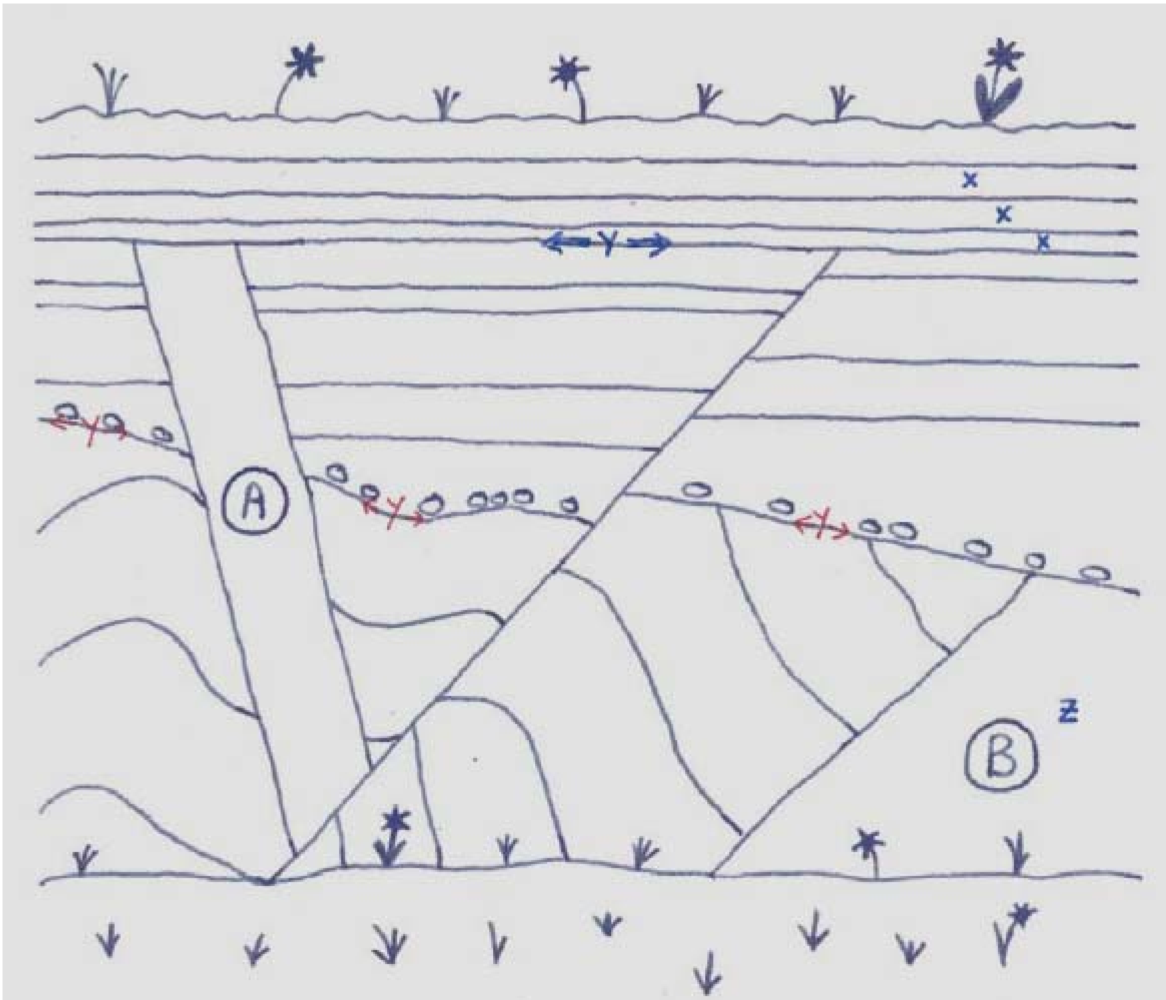
8. A dry log of wood weighs one kilogram. When the tree grew, this mass must have come from somewhere. Write a short explanation (30 words and numbers or less) of where you think most of this mass comes from, and what mass of the raw material is required to make 1 kg of dry wood. State any assumptions you have made.

$\mathbf{CO_2}$	**+**	$\mathbf{H_2O}$	**→**	$\mathbf{CH_2O}$	**+**	$\mathbf{O_2}$
44		**18**		**30**		**32**
~1.5kg		**~0.6kg**		**1kg**		**~1.1kg**

Most of the mass comes from CO_2 and water

NAME (PRINT): ____

9. The figure below represents a cliff face that has exposed a section of geological strata. You can see that two magmas (molten rock) have intruded and subsequently cooled to form igneous rocks marked A and B.



(a) On the diagram, mark with an "X" all the rock layers (strata) that formed AFTER the intrusion of igneous rock A.

(b) At some points during the formation of this geological section the rocks have been subject to erosion. Mark one of these with a "Y".

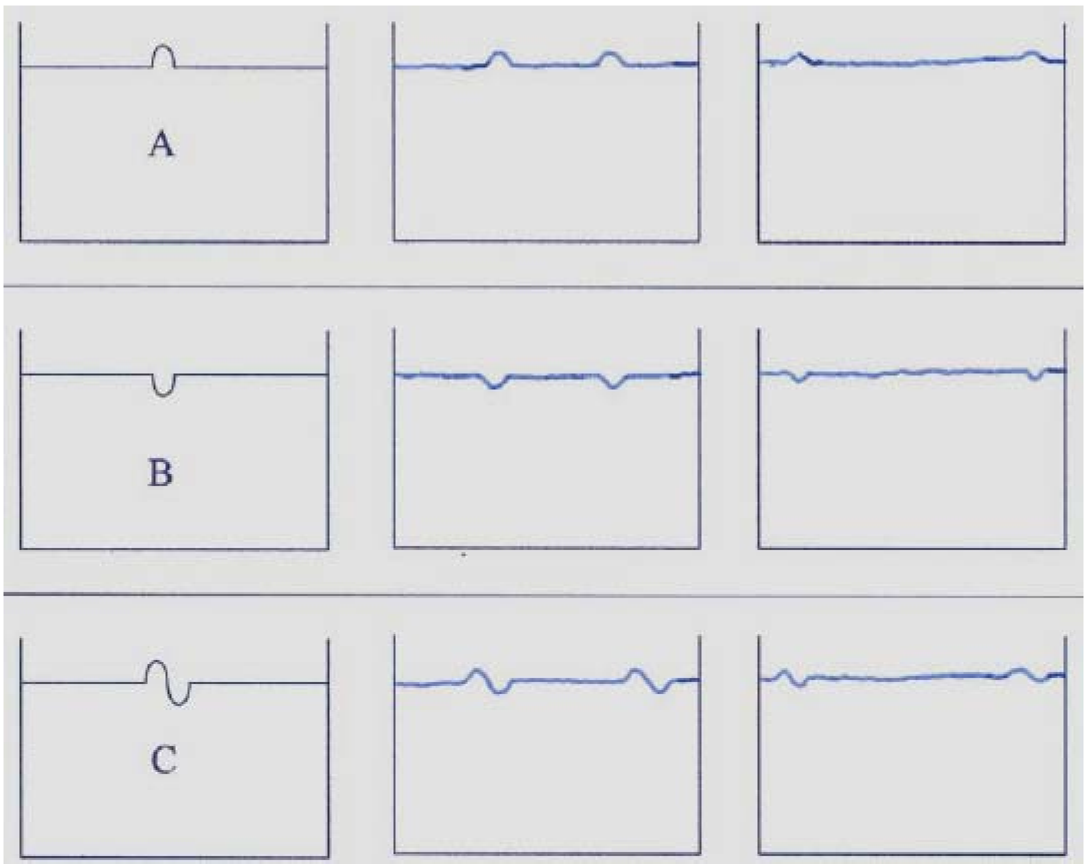
(c) Mark with "Z" the OLDER of the two igneous intrusions.

Please make sure we can see your "X", "Y" and "Z"!

NAME (PRINT): ____

10. Let us try to understand some of the basic physics behind the recent tsunami in the Indian Ocean. Consider a large container full of still water. Look at the top left picture (A). The water surface in the centre has been disturbed, as if a bubble had risen to the surface. Draw in the panels of the top row how the water surface will look at two subsequent times. Do the same for the similar disturbance (B) in the middle row. Now imagine that the two effects are combined (C), and draw in frames of the last row how this disturbance will propagate. The earthquake which caused the recent tsunami produced an initial disturbance similar to this last one.

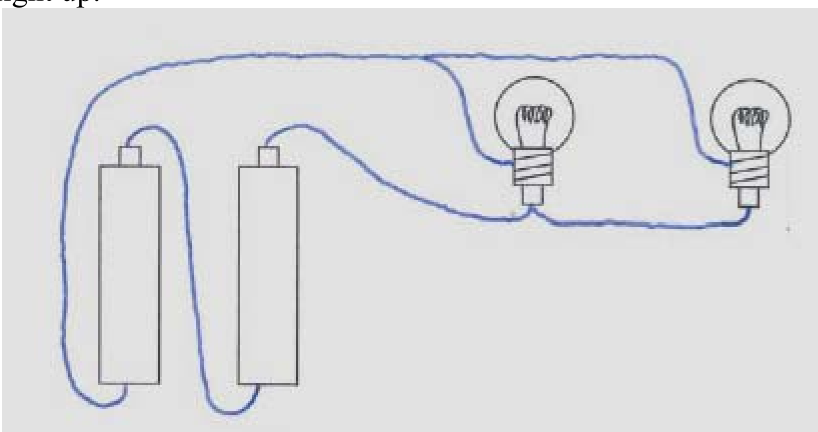
Time t = 0 Time increasing →



Spreading, getting smaller, superposition.

NAME (PRINT): ____

11. You have two 1.5 volt batteries and two bulbs as shown below. Each bulb needs at least 2 volts to light. Draw lines on the picture to show how you would make a circuit in which both bulbs will light up.



The batteries should be in series, the bulbs should be in parallel and the wires connecting them to the batteries should be placed on the correct terminals.

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12. "Gold leaf" is a very thin sheet of gold metal (Au) and has been used for centuries in many cultures to decorate buildings, statues and other works of art. Gold leaf made today is about 1×10^{-7} m thick. If you assume that a single gold atom is a sphere of diameter 3×10^{-10} m and that the gold atoms in such "leaf" were touching each other much as piled-up baseballs might do, how much area could you cover with 100 g of gold leaf?

 **$\sim 2.5 \times 10^{-10}$m**

Volume of one atom ~ $(2.5 \times 10^{-10}\text{m})^3$ m^3
100g gold ~ 3×10^{23} atoms
Volume of 100g ~ 5cm^3 ~ 5×10^{-6} m^3
Area = Volume/Thickness = $5 \times 10^{-6} / 10^{-7}$ ~ 50 m^2