UNIVERSITY OF BRITISH COLUMBIA
Faculty of Science
Science One

NSERC CRSNG

promo Science

Michael Smith National Science Challenge 2008

Monday, April 7th, 2008

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 this examination 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 examination 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 6 questions on 7 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 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 Prof. Chris Waltham, Department of Physics & Astronomy, 6224 Agricultural Road, UBC, Vancouver, BC, V6T1Z1 before the end of **Monday, April 7th, 2008**:

1. students' exam booklets
2. a cheque payable to University of British Columbia, for $5.00 per script returned.

* 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

Celeste Leander, UBC Department of Botany
Andrzej Kotlicki and Chris Waltham, UBC Department of Physics and Astronomy

Translator

Louis Deslauriers, UBC Department of Physics & Astronomy

"It is a small problem merely, but a problem that will agitate the little grey cells most adequately."
- Hercule Poirot

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} 0.08206 L atm K^{-1} mol^{-1}	Constante des gaz
Mass of an electron	m_e	9.10939×10^{-31} kg 5.48580×10^{-4} amu	Masse d'un électron
Mass of a neutron	m_n	1.67493×10^{-27} kg 1.00866 amu	Masse d'un neutron
Mass of a proton	m_p	1.67262×10^{-27} kg 1.00728 amu	Masse d'un proton
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

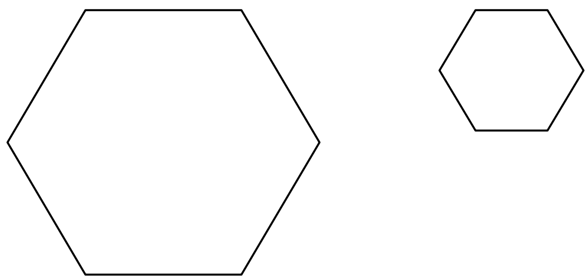
NAME (PRINT): ____

SCHOOL: ____

GRADE: ___________________________ PROVINCE: __________________________

Questions

1. This is a map of two hexagons marked out in the grass on a school playing field.



(a) If it takes you a minute to walk around the edge of the smaller one, how long does it take to walk around the edge of the larger one?

(b) If there are a million blades of grass inside the smaller hexagon, estimate how many there are inside the larger hexagon.

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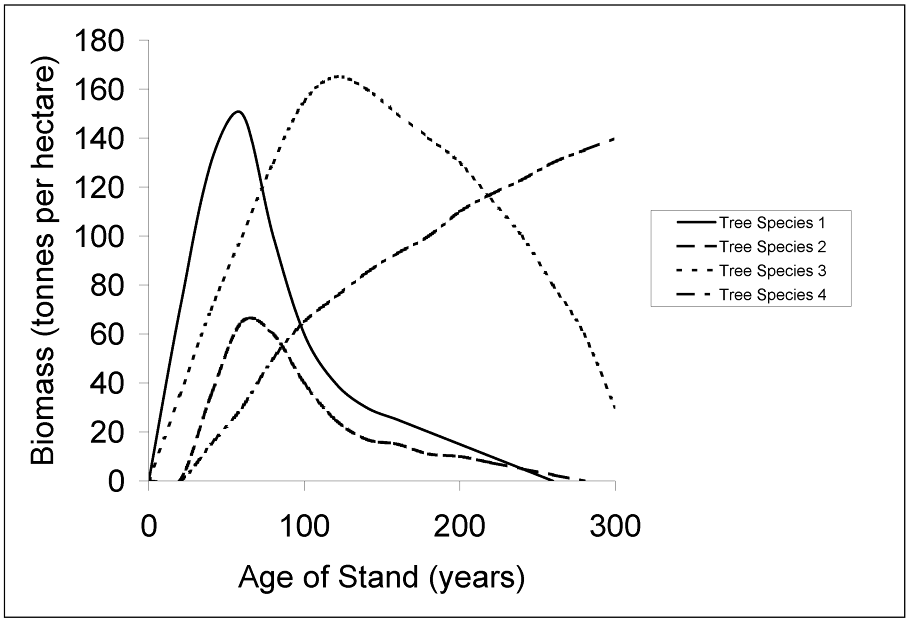
2. (a) A human has genotype $A_1A_1B_1B_2$. What gametes will a single meiosis produce and in what proportions?

(b) A human has genotype $A_1A_2B_1B_2$. What gametes will many meioses produce and in what proportions?

NAME (PRINT): ____

3. The graph shows changes in a community of plants following a disturbance at time zero. The quantity of each species is measured in tonnes per hectare. Just from looking at the graph, suggest a plausible general explanation as to why tree species 1 and 2 disappear. Please answer in two or three sentences.



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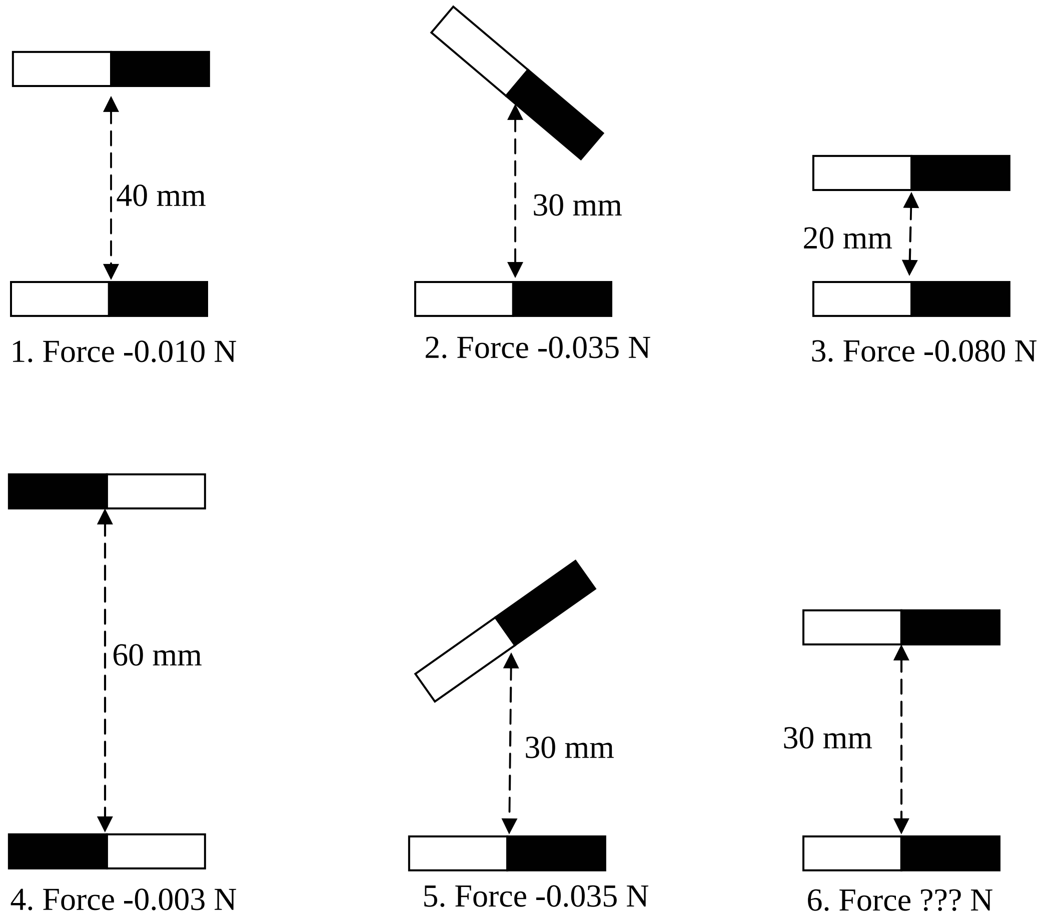
NAME (PRINT): ____

4. You are investigating the nature of the force between two identical magnets by making measurements with the magnets set at various distances and angles with respect to each other. Your measurements are shown below for five cases. The black end of the magnet is north and the white end south. The force measured is that on the lower magnet and the sign convention is that up is positive, and down negative. The distances are measured between the centres of the magnets.

Use these observations to predict the force on the lower magnet in case number 6. Show your working.



NAME (PRINT): ____

5. The Alberta Energy website states “Every two weeks Alberta produces enough coal to fill the Sky Dome in Toronto”. The Skydome is a baseball/football stadium.

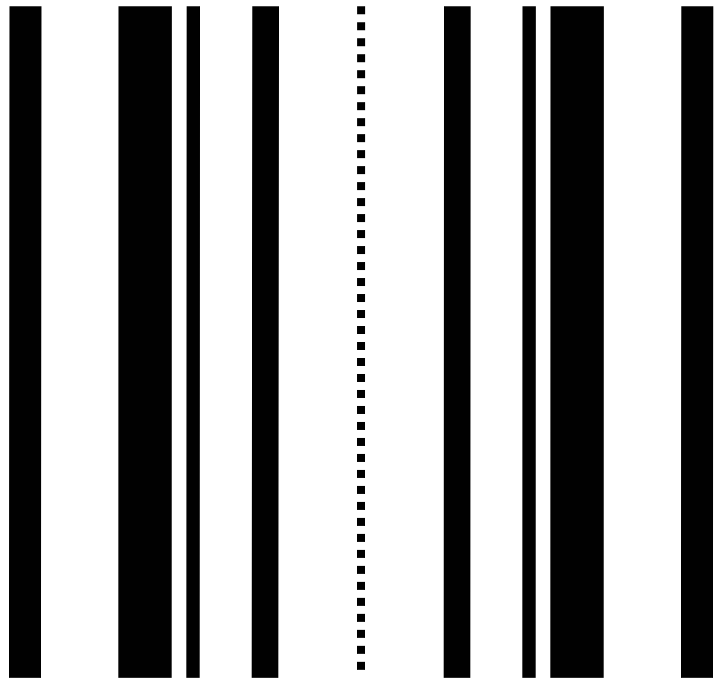
(a) Estimate as best you can the volume of the Skydome, in m^3.

(b) Assuming all this coal is burned, and that coal is mostly carbon, estimate the mass (in tonnes) of carbon dioxide produced by the Alberta coal industry *in a year*.

You can assume a m^3 of coal has a mass of about 1 tonne (1000kg).

NAME (PRINT): ____

6. When the magnetic fields trapped in the rocks of the ocean floor were measured, the following pattern was seen.



The dotted line is the mountainous mid-ocean ridge, running north-south. The white areas and black areas have magnetic field in the opposite direction. One is “normal”, i.e. the magnetic field is the same direction as it is at the ocean surface. The other is reversed, i.e. the magnetic field is opposite what it is at the ocean surface.

(a) What is going on here? (Answer in 20 words or less)

(b) Why is the pattern symmetrical about the mid-ocean ridge?

(c) Do the black stripes have normal or reversed field?