UNIVERSITY OF
BRITISH COLUMBIA
Faculty of Science

NSERC
CRSNG

promo Science

Michael Smith National Science Challenge 2007

Friday, March 30th, 2007

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 10 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 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 mail* the following **2 items** to Prof. Chris Waltham, Department of Physics & Astronomy, 6224 Agricultural Road, UBC, Vancouver, BC, V6T1Z1 before the end of **Friday, March 30th, 2007**:

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
Gordon Bates, UBC Department of Chemistry
Andrzej Kotlicki and Chris Waltham, UBC Department of Physics and Astronomy

English-to-French Translators

David Brandman, UBC Department of Physics & Astronomy
Morgane Cabot, UBC Department of Mathematics

"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

1																	18
1 H 1.008	2											13	14	15	16	17	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	3	4	5	6	7	8	9	10	11	12	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)

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

	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

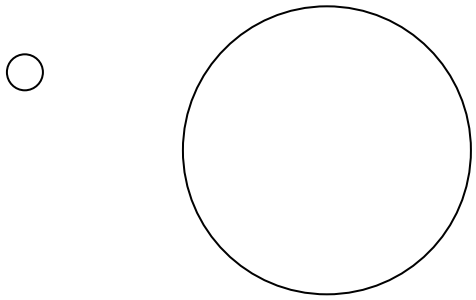
NAME (PRINT): _____

SCHOOL: _____

GRADE: _____ PROVINCE: _____

Questions

1.



(a) The area of the larger circular disc above is ___ times larger than that of the smaller circular disc.

Let the circles above represent spheres rather than discs:

(b) The surface area of the larger sphere above is ___ times larger than that of the smaller sphere.

(c) The volume of the larger sphere above is ___ times larger than that of the smaller sphere.

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2. Here's a table of an object's position as a function of time. It is moving in one dimension only. Sketch a graph of your best estimate of its *velocity*, as a function of time.

t (s)	*x* (m)
3.0	1.0
4.0	2.0
5.0	4.0
6.0	7.0
7.0	11.0

NAME (PRINT): _____

3. Describe the cycling of carbon in the biosphere and the role photosynthetic organisms play. Use 20 words or less, and maybe a simple diagram.

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4. Two healthy parents know from blood tests that each parent carries a recessive allele responsible for a disease.

(a) If their first three children have the disease, what is the probability that their fourth child will not?

(b) Assuming that they have not yet had a child, what is the probability that, if they have four children, all four will have the disease?

NAME (PRINT): _____

5. Four cubes of identical size and mass are made of the following:

- Aluminum painted white
- Aluminum painted black
- Concrete painted white
- Concrete painted black

(a) These blocks are left for several hours on a roof on a sunny summer day. Which one(s) has(have) the highest temperature? Lowest temperature? Or are they all the same?

(b) These blocks are left for several hours in boiling water. Which one(s) has(have) the highest temperature? Lowest temperature? Or are they all the same?

(c) These blocks are left for several hours in boiling water. Immediately after being pulled out, which one(s) *feel* the hottest to your touch? Coolest? Or are they all the same?

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6. For many, hydrogen is considered by many to be the fuel of the future. Fill out as best you can the following table of advantages and disadvantages that hydrogen has compared to gasoline.

Advantages	**Disadvantages**
1	1
2	2
3	3
4	4
5	5

NAME (PRINT): _____

7. According to the bill I received from the gas company I burnt an energy equivalent of 100GJ of natural gas to heat my home last year. Assuming natural gas is methane (CH_4), and it produces 50MJ of heat per kg burnt: what mass of carbon dioxide (CO_2) did I produce in heating my home last year?

_____

8. Estimate, roughly, how many molecules of H_2O fell on Canada last year in the form of snow and rain. Show your work and what assumptions you make.

_____

NAME (PRINT): _____

9. Describe how an earthquake occurs. Use 20 words or less and maybe a simple diagram.

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10. Sketch a graph on the axes below to show the angle of the Sun above and below the horizon over the course of 24 hours at the time of the spring equinox. Imagine you are in Winnipeg, Manitoba (latitude 50°N, longitude 97°W). Let positive values indicate angles above the horizon, and negative values indicate angles below the horizon. The times are local solar time (i.e. the Sun is highest in the sky at 12:00). Put numbers on the vertical axis.