UNIVERSITY OF
BRITISH COLUMBIA
Faculty of Science

NSERC
CRSNG

promo Science

Michael Smith National Science Challenge 2006

Tuesday, April 11th, 2006

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 courier the following **3 items** to Prof. Chris Waltham, Department of Physics & Astronomy, 6224 Agricultural Road, UBC, Vancouver, BC, V6T1Z1 before the end of **Tuesday, April 11, 2006**:
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
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. What is a gene? Give your answer in no more than 10 words.

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2. Draw a labelled diagram that shows how protein synthesis works inside a cell. Be sure to include the following components: ribosome, messenger RNA, several transfer RNAs, several amino acids, growing polypeptide chain (growing protein).

NAME (PRINT): ____

3. A large population of beetles is thought to be in Hardy-Weinberg Equilibrium for a gene with two alleles, a dominant allele for black colour, and a recessive allele for brown colour. If 9% of the animals are found to be brown, what fraction is expected to be heterozygotes?

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4. In 2-5 words, say what you expect the following elements to be like:

(a) Rubidium (Rb)

(b) Ruthenium (Ru)

(c) Xenon (Xe)

They can all be found in the same row of the Periodic Table on page 2.

NAME (PRINT): ____

5. Consider a litre of water:

(a) If the container is a cube, how long are its sides (on the inside)?

(b) What is the approximate mass of the water?

(c) Approximately how many water molecules are in this amount of water?

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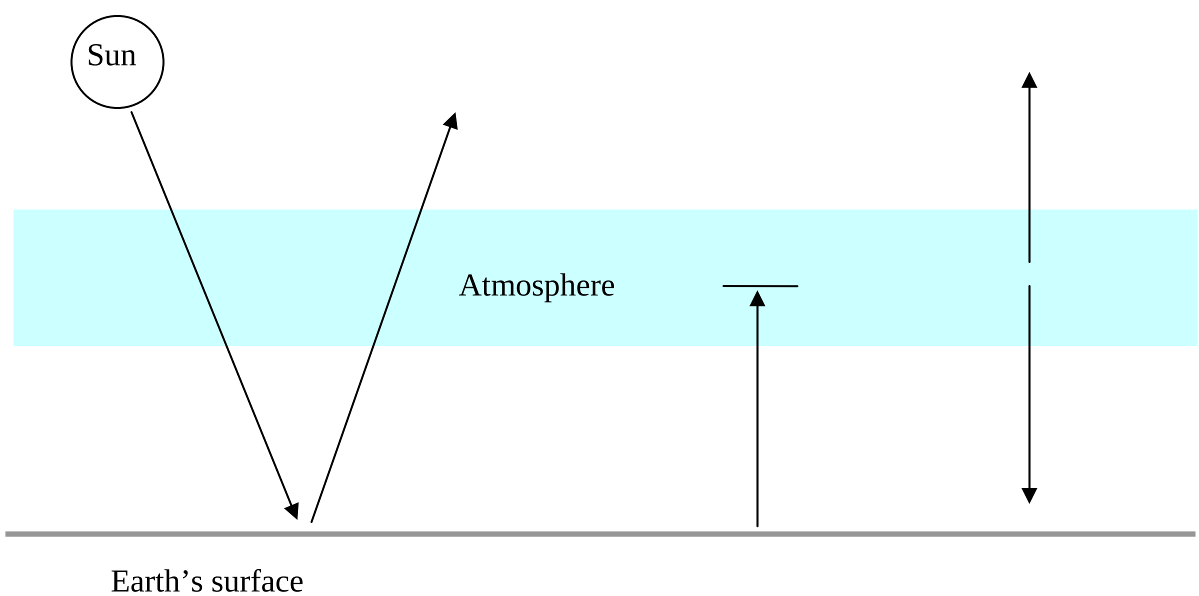
6. Assume gasoline is a hydrocarbon with two hydrogen atoms for each carbon. How many litres of gasoline does one have to burn to produce a tonne of carbon dioxide (CO_2)? (One tonne of liquid gasoline has a volume of 1300 litres).

NAME (PRINT): ____

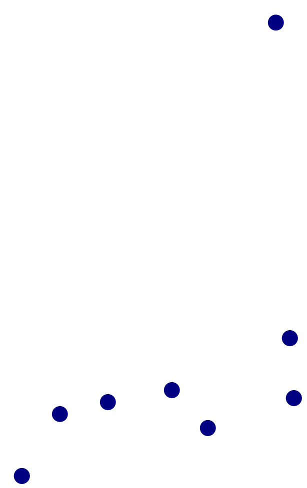
7. Canada's 32.5 million people are responsible for the consumption of 1.4×10^{19} J of energy each year. If all this power had to come from burning gasoline, how many litres per person per day would have to be consumed? The energy content of gasoline is 32 MJ/litre.

8. Label the arrows (only) on this diagram explaining the Greenhouse Effect. Use no more than three words per arrow. (The *lengths* of the arrows are not intended to have any meaning).



NAME (PRINT): ____

9. At a certain time on a clear evening you look north and see Ursa Major (also known as the Great Bear or the Big Dipper) and the Pole Star (top). Draw on the right how these stars will appear six hours later.



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10. A person walks normally at a constant speed in the positive *x* direction. Sketch a graph of the position *x* of the person's left foot as a function of time *t*: