The Michael Smith Grade 10 Science Challenge 2002

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The Michael Smith Science Challenge is a new contest aimed at high school students who are completing Science 10. To our knowledge, no such contest currently exists in Canada. It has been consciously modeled on the highly successful mathematics contests for various grade levels run by the University of Waterloo, and was piloted in British Columbia in April 2002. A total of 301 students took part from 32 high schools throughout the province. It is intended to make the contest available to all Canadian high schools in the spring of 2003.

There are several aims to this project. Firstly, several of the present authors have long experience with the Physics and Chemistry Olympiads, the Chemical Institute of Canada National High School Examination, and the Canadian Association of Physicists High School Examination, all aimed at Grade 12 students. It is our feeling that students attempting these very rigorous examinations would benefit greatly from experience gained at a lower level. In addition, most students participating in these Grade 12 contests are already largely committed to their chosen fields. A contest at the Grade 10 level has the advantage of raising the level of interest in, and awareness of, all branches of science. In particular, we were inspired by the high degree of student interest in mathematics generated by the extraordinarily inventive and popular Gauss contests. If we can have a similar impact on Grade 10 Science, we will have been very successful.

The information we gain from this enterprise will be very useful in several ways. We would like to see what science Grade 10 students have assimilated, and to compare this

with the expectations of university science teachers. This information will assist teaching staff, particularly in introductory courses, and will perhaps initiate a dialogue with the high school science teaching community.

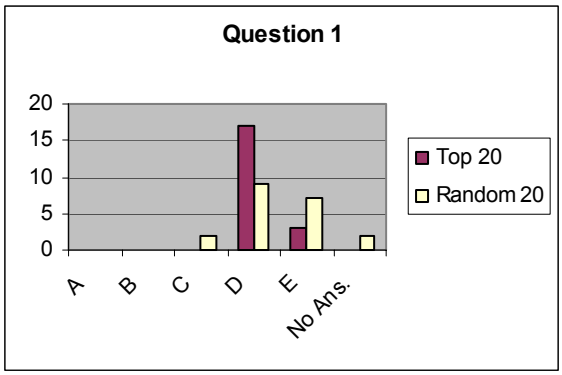
We approached the initiation of this contest in the following way. In late 2001 we prepared two examinations based on the British Columbia Science 10 curriculum. We chose a multiple-choice format, for ease and definiteness of grading. One examination was posted on the web*. Every high school in British Columbia was sent a letter, attention the Grade 10 science teacher, informing them of the forthcoming examination, and directing them to the website. Teachers and students were invited to try this preliminary examination, and to request the solutions and send comments and suggestions by e-mail. Many did so. In early April, the other examination was mailed to each school, with directions that the examination was to be proctored in the school on a certain morning for any grade 10 student wishing to take it. Scripts were mailed back to the University of British Columbia.

During this process, seed funding was secured from the UBC Faculty of Science and each of the participating departments. Crucially, we received the kind permission of Michael Smith's family to use the name of UBC's 1993 Nobel Prizewinner for the contest. In early May, four of the top-scoring students and their parents were invited to a tour of the four participating departments at UBC and to a lunch on campus. Mrs. Helen Smith gave the prizes, and several younger Smith family members, including grandchildren, were also present, making the ceremony a rather relaxed family occasion.

The actual examination is presented below, together with a simple analysis of the answers. The marking scheme is similar to that of the Gauss contests, with some credit given for leaving a question blank rather than guessing. The maximum possible score was 140; top score attained was 115, the mean 70, and the minimum 28. After each question we show a histogram with the distribution of answers for the top 20 scorers, and of 20 randomly chosen from the rest. The difference between these two sets of 20 is sometimes very slight and sometimes very marked. There are cases where the top 20 scorers favoured the correct answer very strongly, and the rest answered almost randomly. The only questions which were answered very poorly, even by the top scorers, were those pertaining to the provincial environment. We consider this to be due to the lack of emphasis in schools on the local environment. This is we think is a problem, of the type that this contest helps to highlight.

In conclusion we feel this was a highly successful pilot project which was enjoyed by all participants - students, teachers and creators. The level of the contest was about right; no-one found it too simple, many did very well, and all were able to do some portion of the examination. We look forward to the results of the first national Grade 10 contest in 2003.

* www.physics.ubc.ca/~waltham/g10exam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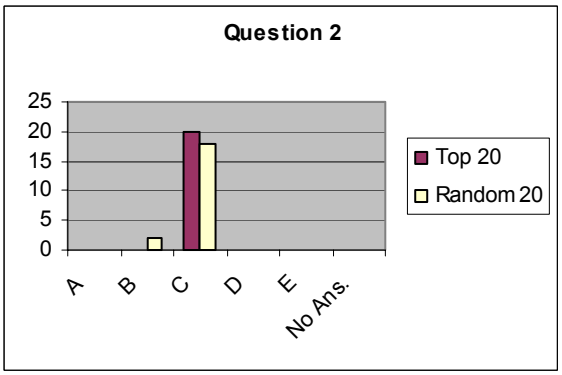
No Ans.
Top 20
Random 20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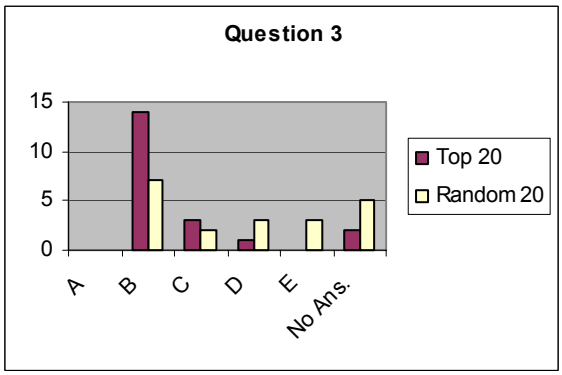
No Ans.
Top 20
Random 20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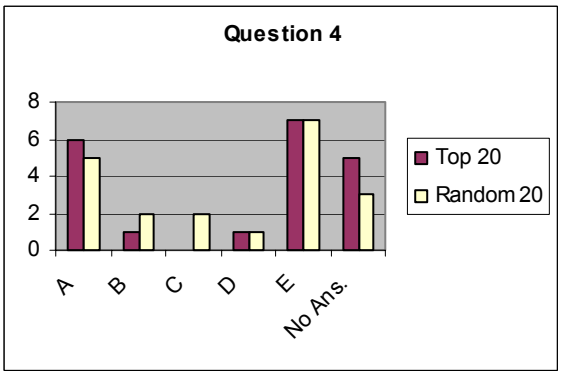
Top 20
Random 20


Question 4
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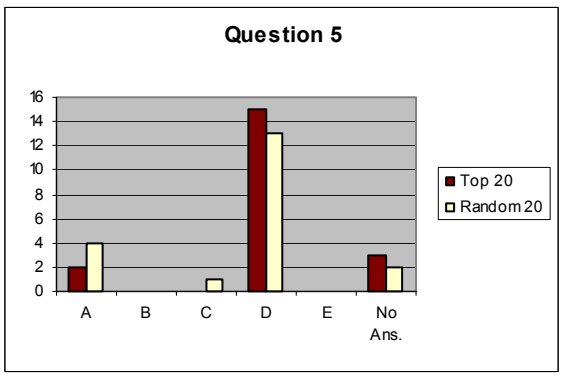
No Ans.
Top 20
Random 20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Top 20
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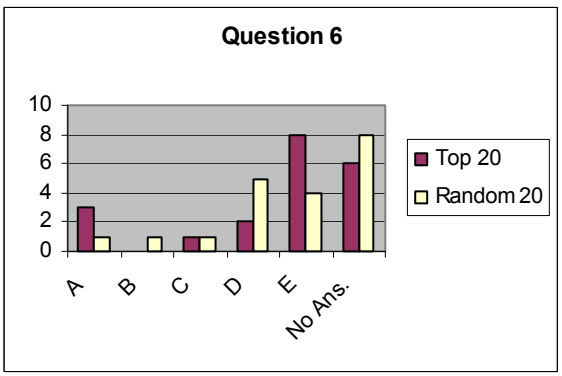
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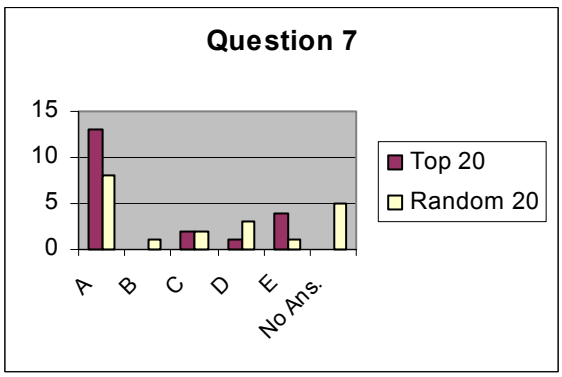
Top 20
Random 20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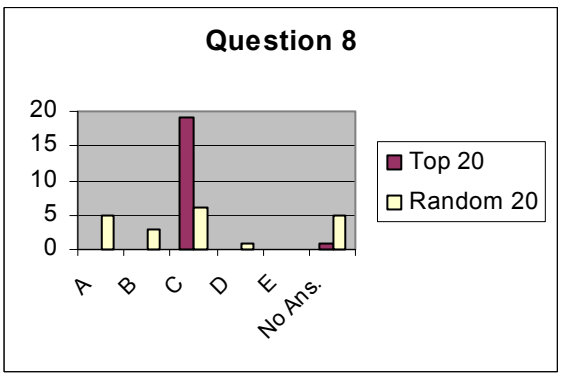
Top 20
Random 20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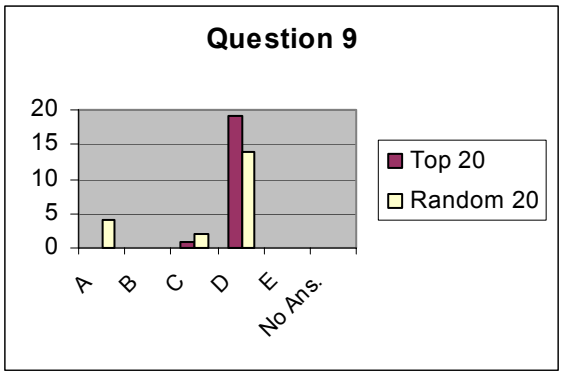
Top 20
Random 20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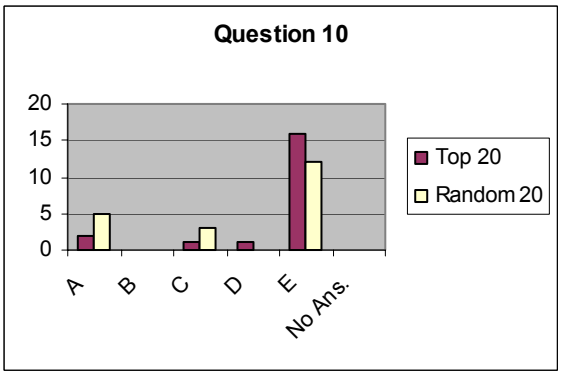
Top 20
Random 20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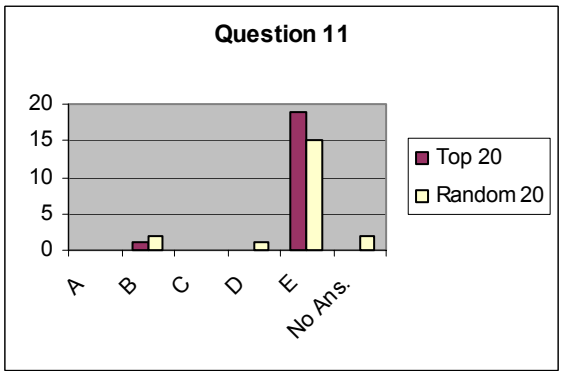
Top 20
Random 20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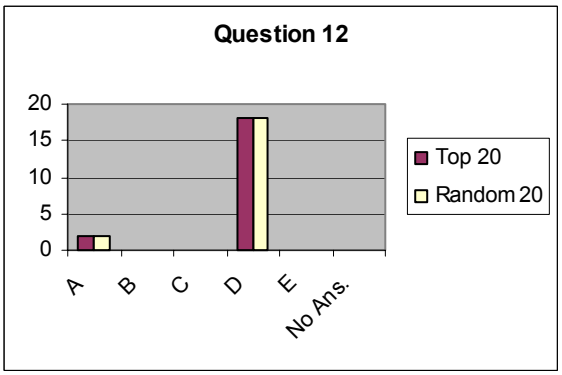
Top 20
Random 20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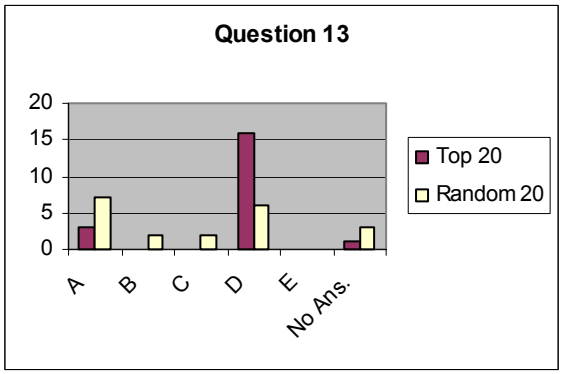
Top 20
Random 20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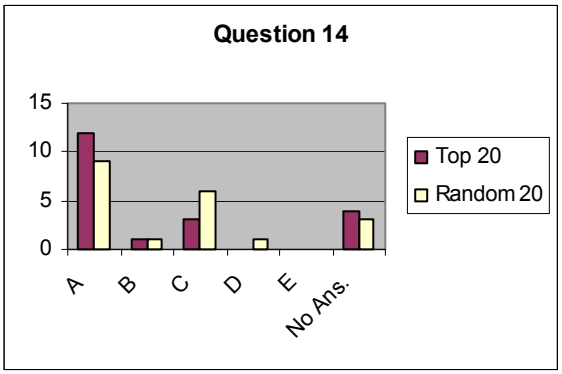
Top 20
Random 20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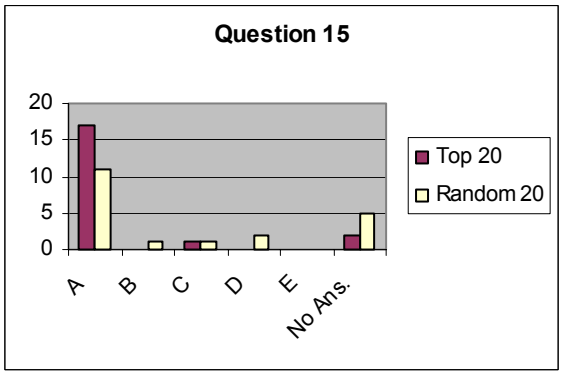
Top 20
Random 20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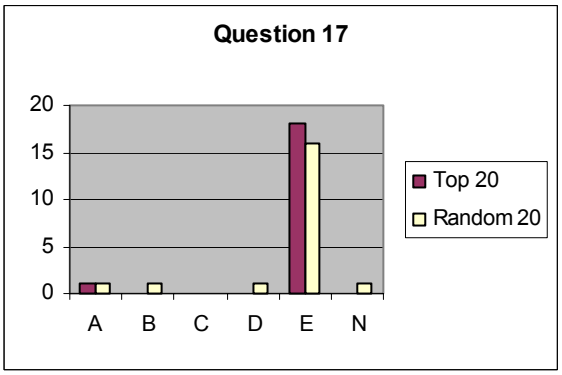
Top 20
Random 20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Top 20
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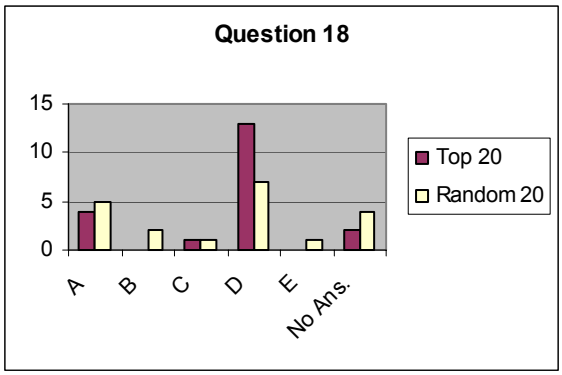
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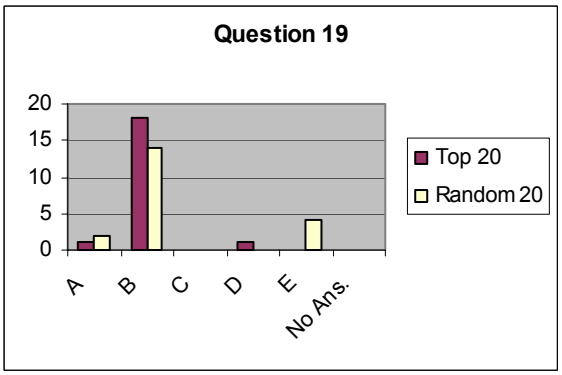
Top 20
Random 20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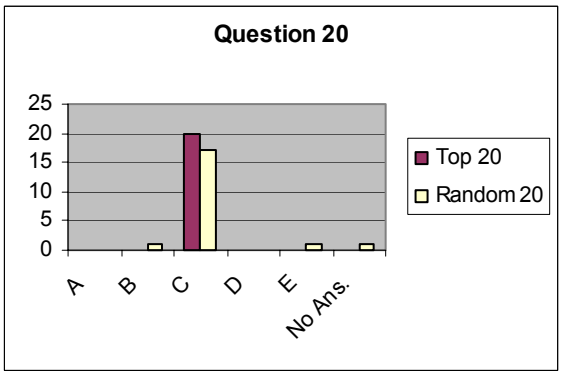
Top 20
Random 20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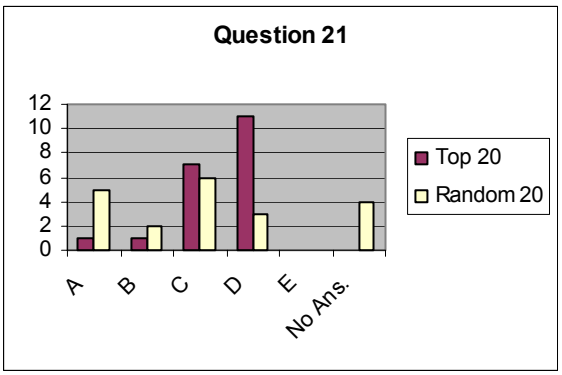
Top 20
Random 20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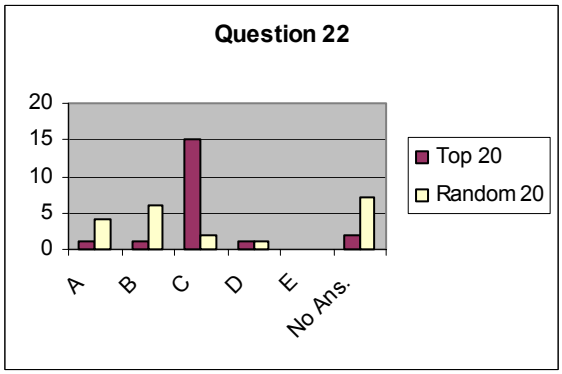
Top 20
Random 20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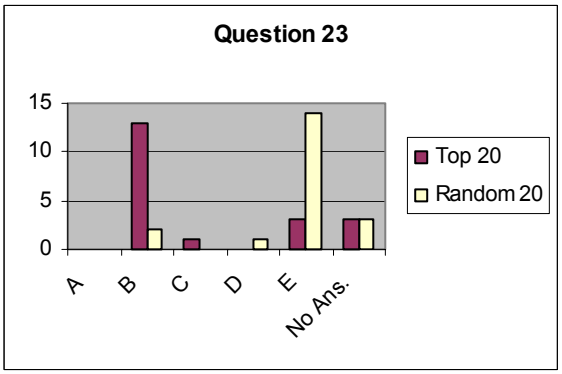
Top 20
Random 20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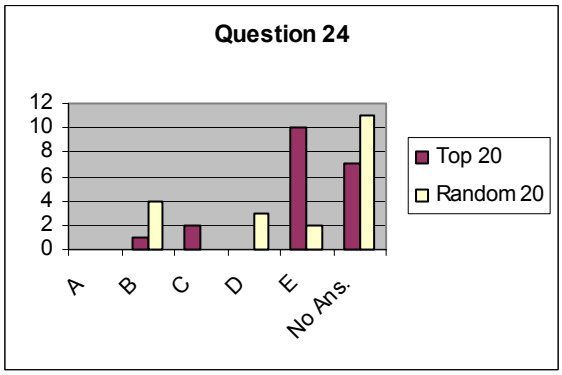
Top 20
Random 20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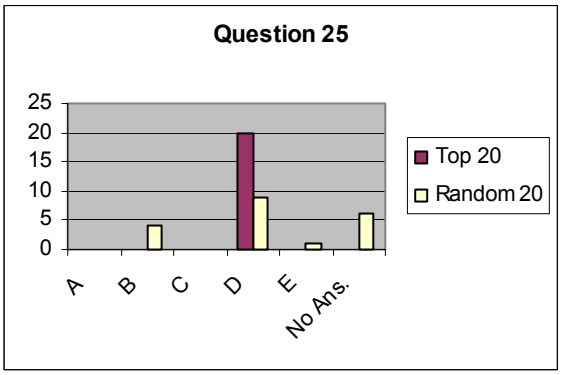
Top 20
Random 20


Question 25
25
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A
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D
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No Ans.
Top 20
Random 20

Michael Smith Science Challenge 2002

A new joint venture of:

- **University of British Columbia Faculty of Science**
  - **Department of Botany**
  - **Department of Chemistry**
  - **Department of Earth and Ocean Science**
  - **Department of Physics and Astronomy**
- **Vancouver School Board/UBC/BC Ministry of Education Transition School**

Instructions

- Calculators are allowed.
- Do not open the exam booklet until you are told to do so.
- Be certain that you understand all the instructions. If you are unsure about something, ask your teacher to explain it.
- The exam contains 7 pages. Check to make sure you have all of them.
- You may use rulers, compasses and paper for rough work.
- The exam is closed book - no notes of any kind, printed or electronic, are allowed
- This is a multiple choice test. Each question is followed by possible answers marked **A, B, C, D, E** (note there may be less than five choices). Only one of these is correct.
- When you have decided on your choice, circle the letter of your choice where it is printed, thus: © . Do not write the letter out again.

Scoring:

- Each correct answer is worth 5 credits in Part A and 8 credits in Part B.
- There is no penalty for an incorrect answer.
- Each unanswered question is worth 2 credits, to a maximum of 20 credits.

- Diagrams are *not* drawn to scale. They are intended as aids to help you solve the problems.
- When your supervisor instructs you to begin, you will have *sixty minutes* in which to finish the exam.

Teachers

- This one-hour exam is to be written by Grade 10 students (or younger) on Tuesday April 9 between 10am and noon.
- Please courier scripts before the end of April 10 to Prof. Chris Waltham, Department of Physics & Astronomy, 6224 Agricultural Road, UBC Campus, Vancouver BC V6T 1Z1.
- Please enclose cheque payable to **University of British Columbia**, for $5.00 *per script* returned.

CEW 2002/03/13

Scoring: There is no penalty for an incorrect answer.
Each unanswered question is worth 2 credits, to a maximum of 20 credits.

Part A (5 credits each)

1. The area of a circle, radius r, is πr^2. What is the surface area of a sphere of the same radius?

A. $2\pi r$
B. πr
C. $2\pi r^2$
D. $4\pi r^2$ *
E. $4/3\ \pi r^3$

2. Why does the sun appear to be the brightest object in the sky?

A. Optical illusion
B. It's the biggest star by far
C. It's our closest star by far *
D. It's the biggest planet by far
E. It's our closest planet by far

3. In cell biology, the final result of a single meiosis is:

A. Large numbers of haploid cells
B. Four haploid cells *
C. Two haploid cells
D. Four diploid cells
E. Two diploid cells

4. Which of the following species is **not** native to B.C.:
Douglas Fir, Gray Squirrel, Banana Slug, Sea Palm, the Elm, Pinyon Pine, Garry Oak, the Holly, Rattle Snake, Marmot, Sturgeon, Fly Agaric (Amanita muscaria).

A. Gray squirrel, Elm, Pinyon Pine, Holly *
B. Gray squirrel, Elm, Garry Oak, Marmot
C. Douglas Fir, Banana Slug, Fly Agaric, Holly
D. Douglas Fir, Banana Slug, Pinyon Pine, Holly
E. Sea Palm, Rattle Snake, Marmot, Sturgeon

5. Animal cells need cholesterol in their cell membrane for stability. Plant cells do not need this because:

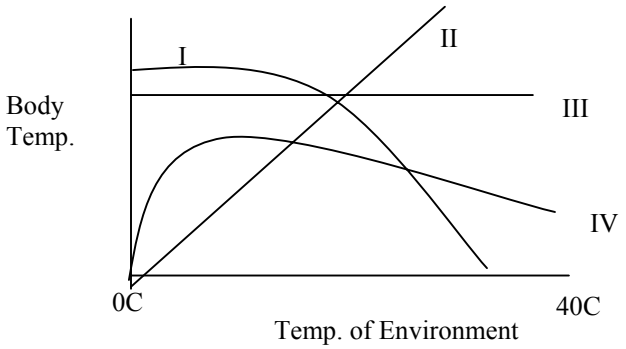
A. they have chloroplasts
B. they do not need oxygen
C. they have a large vacuole containing water
D. they have a cell wall *
E. they do not have flagella.

6. Match the dominant tree species with the various parts of B.C. Write your answers in the spaces below.

Western hemlock (WH)	I. southern coast mountains
Ponderosa pine (PP)	II. northeastern BC
White spruce (WS)	III. Okanagan valley
Arbutus menziesii (AM)	IV. Gulf Islands

A. WH in I; PP in II, WS in III, AM in IV
B. WH in II; PP in I, WS in IV, AM in III
C. WH in IV; PP in I, WS in III, AM in II
D. WH in III; PP in I, WS in II, AM in IV
E. WH in I; PP in III, WS in II, AM in IV *

7. Which of the curves is that of a mouse, and which is that of a snake? Write your answer in the spaces given below.



A. Mouse curve is III; snake curve is II *
B. Mouse curve is I; snake curve is III
C. Mouse curve is I; snake curve is IV
D. Mouse curve is II; snake curve is III
E. Mouse curve is IV; snake curve is II

8. A hydrogen atom consists of one negatively charged electron in orbit around a positively charged proton. If the proton at the centre of a hydrogen atom is bound to a neutron, which is very like a proton but has no charge, what is this new entity?

A. A hydrogen molecule.
B. A helium atom
C. An atom of "heavy hydrogen", chemically similar to ordinary hydrogen but with about twice the mass.*
D. Anti-hydrogen

9. Steam is put into a freezer where it quickly changes to ice because of the great difference in temperature. When this happens, the molecules _____ and the process is called _____.

A. speed up; solidification
B. speed up; sublimation
C. slow down; condensation *
D. slow down; sublimation
E. stay at the same speed; freezing

10. Why is hydrogen considered a family of one in the periodic table of elements?

A. It is the lightest element.
B. It can be explosive.
C. In elemental form it is diatomic and forms H_2.
D. It was the first element discovered.
E. It can easily accept or donate electrons.*

11. Tungsten ions (W^{6+}) and sulphite ions (SO_3^{2-}) react to form what chemical compound?

A. W_2SO_6
B. $W_2(SO_3)_6$
C. W_2S_6
D. W_2SO_6
E. $W(SO_3)_3$ *

12. Select the answer that BEST describes the study of paleontology

A. The study of dinosaurs
B. The study of volcanoes
C. The study of fossils with shells
D. The study of fossils, their ecology and processes of fossilization *

13. We know from fossil evidence that the earliest life on earth probably existed in a _____ atmosphere.

A. oxygenated
B. reducing *
C. low temperature
D. neither a, b or c.

14. The Rocky Mountains around Banff, Alberta contain evidence of which of the following?

A. Large scale thrust faulting *
B. Continuous volcanic activity
C. Subduction
D. Meteorite impact

15. Permian stratigraphic sequences formed prior to the fragmentation of Pangea and now found in western Africa and eastern South America are _____

A. similar *
B. very different
C. composed of marine limestones
D. composed of deep ocean turbidite deposits

16. Which of the following suggests that the Pacific tectonic plate has been moving over geological time?

A. The Hawaiian islands have evolved a unique ecosystem
B. The Hawaiian islands form a chain that becomes progressively older and more eroded towards the island that is currently the most volcanically active
C. All the islands in the Hawaiian chain are the same age
D. The Hawaiian islands follow the trend of the Mid-Atlantic Ridge

NO RIGHT ANSWER

17. This text was taken from a web page advertising a roller coaster:

" You reach the top of the hill and finally realize that being in the front seat wasn't a good idea. You find yourself hanging over the ledge for what seems an eternity, and finally you feel the force of the back cars push you down the steep drop into the most terrifying two and a half minutes of your life"

What is wrong with the physics here?

A. It is the back of your seat, not the back cars, which push you down.
B. It cannot feel like an eternity as the speed is the highest at the top of the hill.
C. The roller coaster ride has to be longer than 2.5 minutes.
D. The roller coaster ride has to be shorter than 2.5 minutes.
E. There's no force pushing you from the back.*

18. Radio waves and visible light rays are both electromagnetic waves. Which of the following is true?

A. Radio waves have shorter wavelengths and higher frequencies than visible light.
B. Radio waves have shorter wavelengths and lower frequencies than visible light.
C. Radio waves have longer wavelengths and higher frequencies than visible light.
D. Radio waves have longer wavelengths and lower frequencies than visible light. *
E. Radio waves have longer wavelengths and the same frequency as visible light.

19. Rainbows are formed because the different colours in sunlight

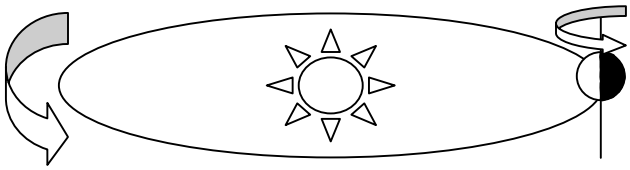
A. refract at different angles on particles of dust or pollution
B. refract at different angles at the boundary between air and water *
C. absorb at different rates in the atmosphere.
D. make an optical illusion.
E. reflect at different angles at the boundary between air and water

20. Water boils at 100C because

A. Everything boils at 100C.
B. At that temperature all the air comes out of the water.
C. At that temperature the water molecules are moving so fast that the attractive force between the molecules can no longer hold them together.*
D. Above that temperature water molecules stick together.
E. The air mixes with the water and makes it a gas.

Part B (8 credits each)
Note: These questions are more difficult and each requires some calculation.

21. A planet rotates once around its own axis in one earth day, and orbits around its star in 100 earth days. Both axes of rotation are in the same direction (i.e. there's no tilt) and the planet spins in the same direction as it travels around its orbit. For an inhabitant of the planet, how long is it between successive sunrises?



A. 0.5 earth days
B. 0.99 earth days
C. 1 earth day
D. 1.01 earth days *
E. 100 earth days

22. Your mass is 50 kg and you climb up Grouse Mountain, on a trail known to Vancouverites as the Grouse Grind. The trail is 2.1 km long, and the height gain is 800 m. How much work do you do against the gravitational field of the earth?

A. 39.2 kJ
B. 103 kJ
C. 392 kJ *
D. 1.03 MJ
E. 392 MJ

23. If a plant is of genotype Aa Bb selfed, and if the genes are on different chromosomes, what proportion of progeny will have the phenotype of both the dominant alleles A and B?

A. 1/2
B. 9/16 *
C. 3/4
D. 5/8
E. 1/4

24. Assuming that gasoline is 100% isooctane (C_8H_{18}), with a density of 0.692 g/mL, what mass of carbon dioxide is added to the atmosphere by the complete combustion of 4.80×10^9 L of gasoline (the approximate annual consumption of gasoline in Canada)? You will need to write the balanced chemical equation for the combustion of isooctane to produce water vapour and carbon dioxide gas. Atomic masses are as follows: H=1, C=12, O=16.

A. 1.02×10^2 kg
B. 1.02×10^4 kg
C. 1.02×10^6 kg
D. 1.02×10^8 kg
E. 1.02×10^{10} kg *

25. John Joly (1857 – 1933) was an Irish professor who believed that the age of the Earth could be calculated by estimating how much sodium and other salts had been added to an originally fresh water ocean. Under Joly's hypothesis, salt would be added to the "primordial fresh water ocean" via erosion of salts contained in rocks and transported to the oceans by rivers. Using Joly's figures there would be 1.418×10^{16} metric tonnes of sodium in the oceans in 2002 with an additional 1.427×10^{8} metric tonnes of sodium added via erosion of rocks each year.

How old would the Earth be if we follow Joly's hypothesis?

A. About 6 000 years
B. More than 4000 000 000 years
C. About 1 000 000 years
D. About 100 000 000 years *
E. About 5 000 000 years