8th International Junior Science Olympiad
Durban, South Africa

Multiple Choice Examination

3 December 2011

Duration: 3 hours **Total Marks:** 30

EXAMINATION RULES

1. All competitors must be present at the front of the examination room 15 minutes before the examination starts.
2. No competitors are allowed to bring any stationery and tools except his/her personal medicine or any personal medical equipment.
3. Each competitor has to sit at his or her designated desk.
4. Before the examination starts, each competitor has to check the stationery and any tools (pen, ruler, calculator) provided by the organiser.
5. Each competitor has to check the question and answer sheets. Raise your hand, if you find any missing sheets. Start after the bell rings.
6. During the examination, competitors are not allowed to leave the examination room.
7. If a competitor needs to use the bathroom he/she must raise his/her hand and an examination supervisor will escort you.
8. The competitors are not allowed to communicate with other competitors and disturb the examination. In case any assistance is needed, a competitor may raise his/her hand and the nearest supervisor will come to help.
9. There will be no questions or discussion about the examination problems. The competitor must stay at his/her desk until the time allocated for the examination is over, although he/she has finished the examination earlier or does not want to continue working.
10. At the end of the examination time there will be a signal (the ringing of a bell). You are not allowed to write anything on the answer sheet, after the allocated time is over. All competitors must leave the room quietly. The answer sheet must be left on your desk.

Read the following instructions carefully:

1. The time available is 3 hours.
2. The total number of the questions is 30. Check that you have a complete set of the test questions and the answer sheet. This question paper consists of 18 pages.
3. Use only the pen provided.
4. Write your name, seat number, country and signature on your answer sheet.
5. Carefully read each problem and choose your correct answer by crossing one of the capital letters on your answer sheet. There is only one right answer for each problem.

   Example:

1	A	B	C	D

6. If you want to change your answer, you have to circle the first answer and then cross a new letter as your correct answer. You are only allowed to make one correction per problem.

   Example:

1	A	B	C	D

   A is the first answer and D is the corrected answer.

7. The reverse side of the question paper may be used for rough work.
8. After completing your answers, your answer sheet should be left on your desk.
9. Grading rules**:**
   - Correct answer : + 1.00 point
   - Wrong answer : : -0.25 point
   - No answer : 0 point

DATA:

acceleration due to gravity on earth = 9.81 m s^{-2}

A periodic table is provided on the last page of this Question Paper.

1. Why can a person not swallow food and talk at the same time?

   A. The brain cannot control two activities at the same time.

   B. In order to speak, air must come through the pharynx to form sounds.

   C. In order to swallow, the epiglottis must close off the larynx (trachea).

   D. Both B and C are correct.

2. Some micro-organisms are pathogenic because they cause diseases. Study the following table which shows a list of diseases in humans in Column X. In Column Y, the main causative agents of the diseases are listed in an incorrect sequence.

Column X	Column Y
(a) Food poisoning (Botulism)	I. Fungus
(b) AIDS	II. Protozoan
(c) Mycosis	III. Bacterium
(d) Malaria	IV. Virus

   The correct sequence of the main causative agents, which match diseases (a), (b), (c) and (d) respectively, may be represented by …

   A. III; II; IV; I

   B. III; IV; I; II

   C. I; IV; II; III

   D. IV; III; I; II

3. The following ecological pyramids represent the number of organisms involved in feeding relationships.

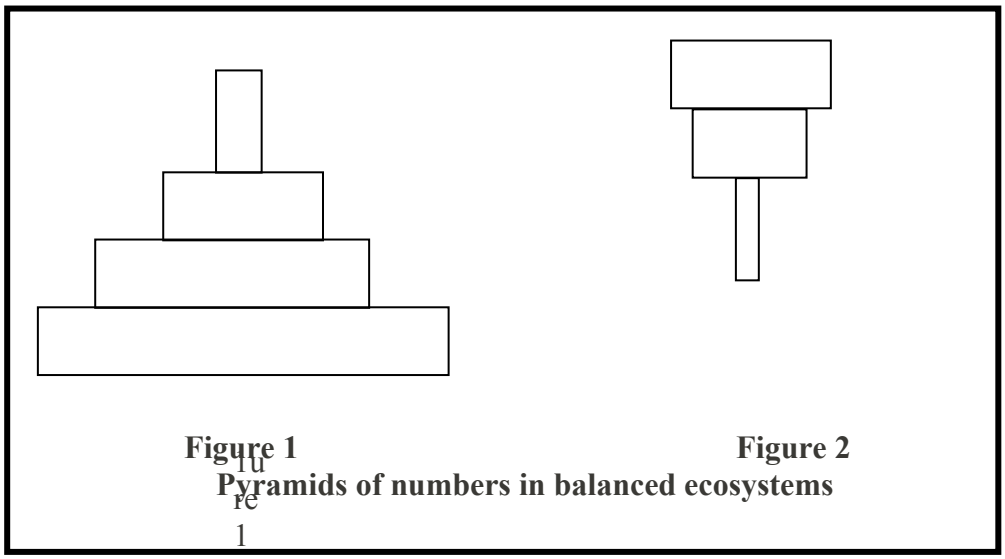


Figure 1 **Figure 2**

Pyramids of numbers in balanced ecosystems

Choose the LETTER (A, B, C or D) which is most likely to represent the organisms in each of the figures.

	Figure 1	**Figure 2**
A.	grass → locust → snake → frog	grass → locust → frog
B.	tree → ant → spider → lizard	tree → bird → parasites
C.	grass → locust → frog → snake	tree → bird → parasites
D.	snake → frog → locust → grass	tree → ant → spider

4. According to Darwin's theory, the more closely related two different organisms are:

A. the more similar their habitats.

B. the less similar their DNA sequence.

C. the more recently they shared a common ancestor.

D. the more similar they are in size.

5. Examine the two graphs (Figures 3 and 4) which were provided by the Department of Environmental Affairs in South Africa. The graphs show the average temperature increase during the period 1975 to 2010, and related species decline in South Africa.

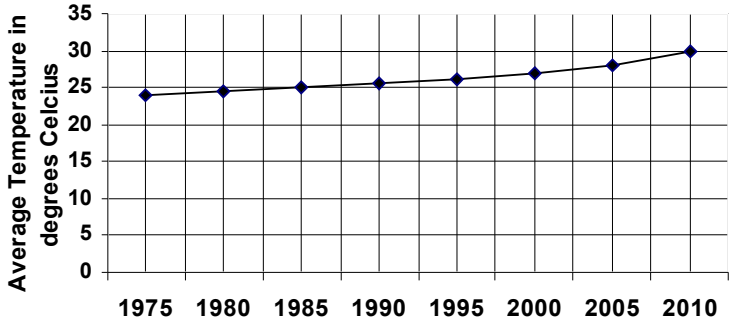


Figure 3

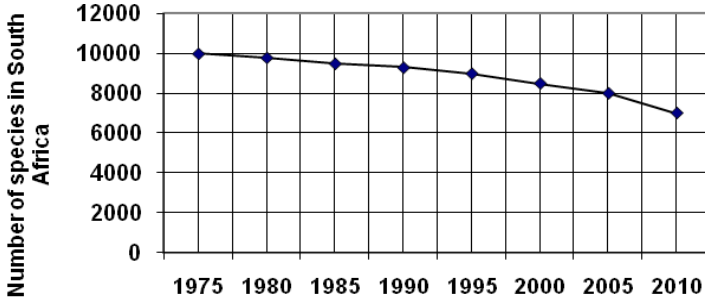


Figure 4

It can be deduced that, during the period 1995 to 2005:

A. an average temperature increase of 10 °C resulted in extinction of 2000 species.

B. an average temperature increase of 2 °C resulted in extinction of 3000 species.

C. an average temperature increase of 5 °C resulted in extinction of 2000 species.

D. an average temperature increase of 2 °C resulted in extinction of 1000 species.

6. Stem cells are self-renewing, undifferentiated cells that divide by mitosis to produce specific body cell types. There are two broad types of stem cells, namely, adult and embryonic.

Which of the following is correct?

A. An injury to the nerves of the spinal cord can always be corrected by adult stem cells.

B. Embryonic stem cells cannot differentiate into adult nerve cells.

C. Embryonic stem cells can potentially replace damaged nerve cells of the spinal cord.

D. All the above statements are correct.

7. Consider Figure 5, the graph comparing the effectiveness of different methods of contraception.

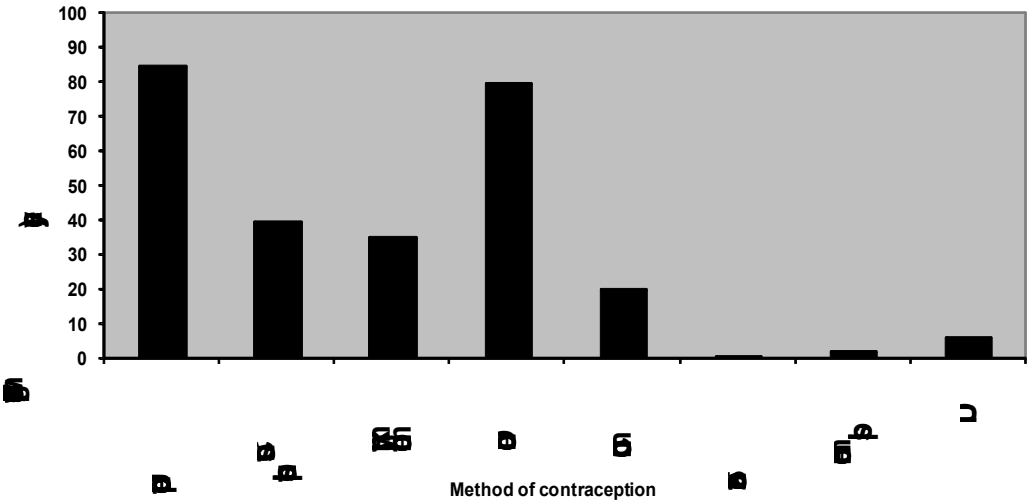


Figure 5

Which of the following statements is correct?

A. The sterilization and douche methods can be considered good methods of avoiding pregnancy.

B. The condom is completely effective in preventing pregnancy.

C. Ninety eight percent of pregnancies can be prevented by using hormone pills.

D. The contraceptive success rate of the rhythm method, where sex is avoided during ovulation is about 35%.

8. The diagram below (Figure 6) shows two slides numbered 1 and 2, prepared from different parts of the same plant, numbered 3. The slides were prepared from tissues

that were undergoing cell division. On each slide, cells in various stages of cell division can be seen.

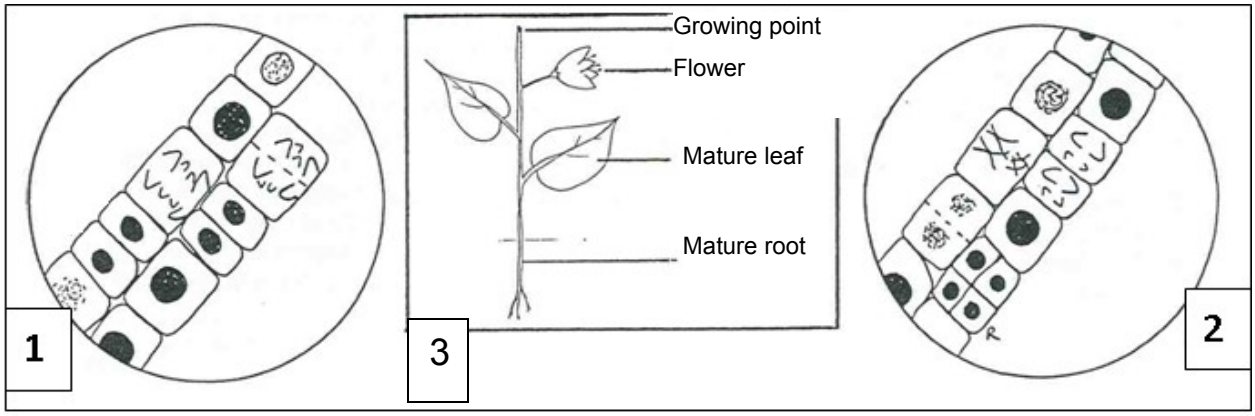


Figure 6

The slide that shows meiosis is _____, and it was prepared from the _____ of the plant:

A. Slide 1, Growing point
B. Slide 2, Growing point
C. Slide 2, Flower
D. Slide 1, Flower

9. Huntington's disorder is a rare defect caused by an autosomal **dominant allele**. The defect occurs on chromosome 4 and causes a part of DNA, called a CAG sequence repeat, to occur many more times than it is supposed to. Normally, this section of DNA is repeated 10 to 28 times. But in persons with Huntington's disease, it is repeated 36 to 120 times. As the gene is passed down through families, the number of repeats tends to get larger.

If a married couple has four children, and two of the children have the disorder, which of the following is correct about the genotypes of the parents?

A. Both parents are heterozygous for the disorder.

B. One parent is homozygous for the disorder, and the other parent does not have the disorder.

C. One parent is heterozygous for the disorder, and the other parent does not have the disorder.

D. Both A and C could be correct.

10. Two groups of tomatoes were grown under laboratory conditions, one with compost added to the soil and one a control without the compost. The leaves of the plants grown without compost were yellowish (less green) than those of the plants growing in compost-enriched soil. The best explanation for this difference is that:

A. The compost made the soil more loosely packed, so the plants' roots would grow with less resistance.

B. The compost contained minerals such as magnesium and iron needed for the synthesis of chlorophyll.

C. The heat released by the decomposing leaves of the compost caused more rapid growth and chlorophyll synthesis.

D. The plants absorbed chlorophyll from the compost.

11. The change in the oxidation state of Mn in MnO_4^- and O in H_2O in the following redox reaction,

$$4MnO_4^-(aq) + 2H_2O(\ell) \rightleftharpoons 4MnO_2(s) + 3O_2(g) + 4OH^-(aq),$$

is:

A. Mn^{+7} to Mn^{+2} and O^{-2} to O^-

B. Mn^{+7} to Mn^{+4} and O_2^- to O^0

C. Mn^{+7} to Mn^{+2} and O^{-2} to O_2^{-2}

D. Mn^{+7} to Mn^{+4} and O^{-2} to O^0

12. The atomic mass of a hypothetical element X is 33.42 amu. A 27.22 g sample of X combines with 84.10 g of another hypothetical element Y to form the compound XY. The atomic mass of Y is:

A. 68.50 amu

B. 69.84 amu

C. 103.3 amu

D. 111.3 amu

13. For the complete combustion of 47 g of gasoline (octane, C_8H_{18}), the mass of oxygen consumed is:

A. 69.20 g

B. 82.45 g

C. 138.5 g

D. 164.9 g

14. The average relative atomic mass of chlorine is 35.45. It consists of two naturally occurring isotopes chlorine-35 and chlorine-37. What is the fractional abundance of chlorine-37?

A. 0.3650 **B.** 0.2200 **C.** 0.2250 **D.** 0.4500

15. Which of these pairs of ions will have the same total number of electrons?
(i) Na^+ and Mg^{2+} (ii) F^- and Cl^- (iii) O^- and O^{2-} (iv) Ga^{3+} and Fe^{3+}

A. (i), (ii)

B. (i) only

C. (i), (ii), (iii)

D. (i), (ii), (iii), (iv)

16. Based on general trends in the periodic table, predict which element in each of the following pairs has the most metallic character.
(i) Sn or Pb (ii) Ag or Sr (iii) Al or B (iv) Br or As

A. (i) Pb (ii) Sr (iii) Al (iv) As

B.	(i) Sn	(ii) Ag	(iii) B	(iv) As
C.	(i) Pb	(ii) Ag	(iii) Al	(iv) Br
D.	(i) Sn	(ii) Sr	(iii) B	(iv) Br

17. What is the molarity of $ZnCl_2(aq)$ that forms when 15.0 g of Zn completely reacts with $CuCl_2(aq)$ producing a final volume of 175 mL of solution according to the reaction:

$$Zn(s) + CuCl_2(aq) \rightarrow ZnCl_2(aq) + Cu(s)$$

A. 1.31 M
B. 0.0400 M
C. 0.629 M
D. 0.0857 M

18. The empirical formulas of the compounds formed by
(i) sodium and sulfur (ii) strontium and oxygen
(iii) potassium and chromate (iv) calcium and hydrogen phosphate
are:

A.	(i) NaS	(ii) SrO_2	(iii) $K_2Cr_2O_4$	(iv) $Ca(HPO_4)_2$
B.	(i) Na_2S	(ii) SrO	(iii) K_2CrO_4	(iv) $CaHPO_4$
C.	(i) Na_2S_2	(ii) Sr_2O	(iii) $KCrO_4$	(iv) Ca_2HPO_4
D.	(i) Na_3S_2	(ii) SrO_3	(iii) K_2CrO_4	(iv) $Ca_2(HPO_4)_3$

19. Calculate the pH of the resulting solution when 25 mL of a 0.05 M NaOH solution is added to 50 mL of a 0.01 M HCl solution.

A. 2.8
B. 12.5
C. 2.0

D. 12.0

20. Which of the following statements are *correct or incorrect* with regards to intermolecular forces.

(i) Intramolecular forces stabilize individual molecules while intermolecular are responsible for the bulk properties of matter.

(ii) The strength of ion-dipole forces are responsible for the dissolution of ionic salts in non-polar solvents.

(iii) Van der Waals forces are present in both polar and non-polar molecules.

(iv) Viscosity decreases with weak intermolecular forces and increases with low temperature.

A.	(i) correct	(ii) incorrect	(iii) correct	(iv) correct
B.	(i) incorrect	(ii) correct	(iii) correct	(iv) correct
C.	(i) correct	(ii) incorrect	(iii) incorrect	(iv) correct
D.	(i) correct	(ii) correct	(iii) incorrect	(iv) incorrect

21. The Tau Tona gold mine in Carltonville, South Africa is the deepest mine in the world with a depth of 3.9 km. If, on the surface of the mine, a simple pendulum has a period of 1.4 s and the reading on a barometer is 101 kPa, which one of the following statements regarding the period of the pendulum and the reading on the barometer at the bottom of the mine is correct?

	Period of pendulum	**Reading on barometer**
A.	greater than 1.4 s	greater than 101 kPa

B.	less than 1.4 s	less than 101 kPa
C.	greater than 1.4 s	less than 101 kPa
D.	less than 1.4 s	greater than 101 kPa

22. A long solenoid with closely spaced turns carries a direct electric current. Each turn of wire exerts:

A. an attractive force on the next adjacent turn.

B. a repulsive force on the next adjacent turn.

C. zero force on the next adjacent turn.

D. either an attractive or a repulsive force on the next adjacent turn, depending on the direction of current in the solenoid.

23. The world class Moses Mabhida football stadium situated in Durban has a symmetrical arc of length 350 m and a height of 106 m, as shown in the picture below on the left.

The picture on the right shows a funicular (Skycar), which takes tourists to the top of the arc. Suppose that the Skycar with tourists inside, starts from the base of the arc and travels a distance of 175 m along the arc to the viewing platform at the top. Assume that the work done by friction during the Skycar's complete ascent is 5.8×10^5 J. If the combined mass of the Skycar and tourists is 5000 kg, then the work done by the motor that lifts the Skycar is approximately equal to,

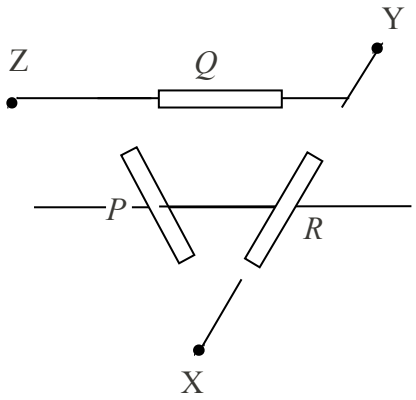
A. 4.6×10^6 J

B. 5.8×10^6 J

C. 8.0×10^6 J

D. 9.2×10^6 J

24. The diagram shows a circuit consisting of three identical resistors, *P*, *Q* and *R*, each of resistance 4.0 Ω and connected as shown. If 3.0 A of current flows into point X in the circuit and 3.0 A flows out at point Y, then the power generated by resistor *R* is approximately



A. 36 W

B. 4.0 W

C. 16 W

D. 9.0 W

25. Figure 1 shows a metallic disc with a hole at its centre. Which one of the figures from 2 to 5 schematically shows how the disc will appear after it is uniformly heated?

Figure 1

Figure 2

Figure 3

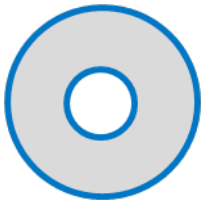


Figure 4

Figure 5

A. Figure 2

B. Figure 3

C. Figure 4

D. Figure 5

26. The difference between the time you see the flash of lightning and the time you hear the thunder is Δt in seconds. Taking the speed of sound in air as 340 m s^{-1} and the speed of light in a vacuum as 3×10^8 m s^{-1}, the approximate distance in kilometers between you and the lightning flash is

A. $\frac{\Delta t}{2}$

B. $\frac{\Delta t}{3}$

C. $\frac{\Delta t}{4}$

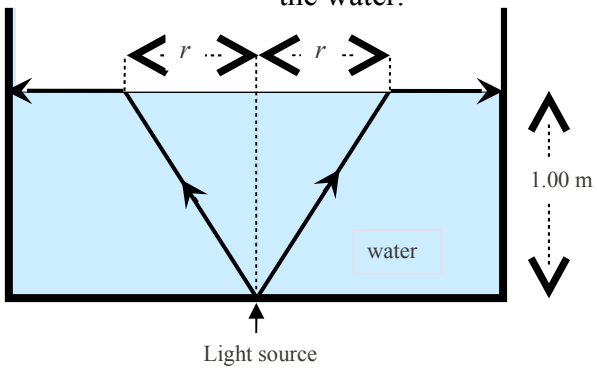
D. $\frac{\Delta t}{5}$

27. South Africa is bidding to host the world's most powerful radio telescope, the Square Kilometre Array (SKA) in Southern Africa. With its estimated 3000 radio antenna dishes, the SKA will provide continuous frequency coverage from 70 MHz to 10 GHz.

Consider a certain absorption line when analyzing the spectrum of a particular galaxy. If the difference between the measured wavelength (λ), and the rest wavelength (λ') as measured in the laboratory, of the absorption line is 50×10^{-10} m and the ratio λ/λ' is 1.01, at what speed is the galaxy receding from us and would SKA be able to detect this absorption line?
(Speed of light in vacuum is 3×10^8 m s^{-1}.)

	Approximate speed of galaxy	**Would SKA detect this absorption line?**
A.	3000 km/s	Yes
B.	3000 km/s	No
C.	300 km/s	No
D.	300 km/s	Yes

28. A point source of light is placed at the bottom of a tank of water 1.00 m deep such that it emits light rays upward in all directions. A circle of light is formed by the rays that are refracted into the air and the rays outside of this circle are reflected back into the water.



Given that the index of refraction of water is 1.33, the radius *r* of the circle at the surface of the water is approximately,

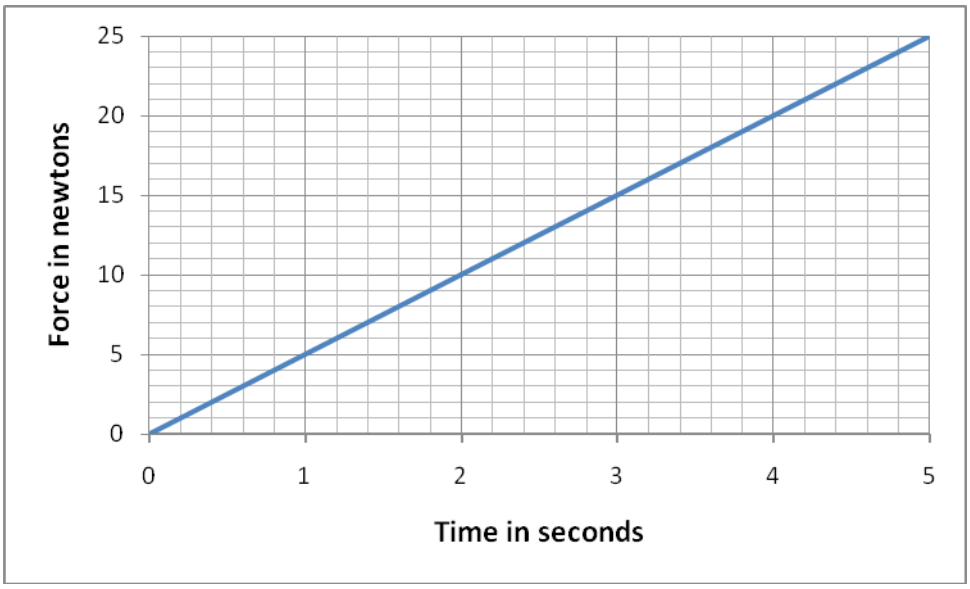
A. 1.33 m

B. 1.00 m

C. 1.14 m

D. 0.75 m

29. A variable force is exerted on a body of constant mass. The body, initially at rest, moves in a straight line. The following graph shows how the force varies with time. All frictional forces are ignored.



If the velocity of the object is 7.0 m s^{-1} after 2.0 s, the velocity after 3.4 s will be approximately

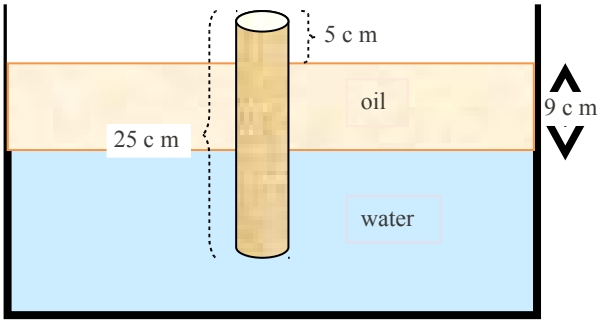
A. 11.9 m s^{-1}

B. 17.0 m s^{-1}

C. 20.2 m s^{-1}

D. 28.9 m s^{-1}

30. An oil layer which is 9 cm deep lies above a depth of water. A uniform cylinder of wood of length 25 cm is floating vertically upright in the two liquids as shown in the diagram. If 5 cm of the wooden cylinder lies above the oil surface, what is the density of the wood?
(The density of the oil is 0.9 g cm^{-3} and density of water is 1.0 g cm^{-3}.)



A. 0.76 g cm^{-3}

B. 0.66 g cm^{-3}

C. 0.80 g cm^{-3}

D. 0.70 g cm^{-3}

END OF QUESTIONS

Periodic Table

1	2											13	14	15	16	17	18
1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31	3	4	5	6	7	8	9	10	11	12	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	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** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** 98.91	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57* **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89** **Ac** (227)	104 **Db** (261)	105 **Jl** (262)	106 **Rf** (263)	107 **Bh** (262)	108 **Hn** (?)	109 **Mt** (?)									

* **Lanthanide Series**	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (147)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.2	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
** **Actinide Series**	90 **Th** (232)	91 **Pa** (231)	92 **U** (238)	93 **Np** (237)	94 **Pu** (239)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (252)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (256)	102 **No** (259)	103 **Lr** (260)