INDIAN INSTITUTE OF SCIENCE
BANGALORE - 560012

ENTRANCE TEST FOR ADMISSIONS - 2010

Program : Research

Entrance Paper : Atmospheric Sciences

Paper Code : AS

Day & Date
SUNDAY, 25TH APRIL 2010

Time
9.00 A.M. TO 12.00 NOON

GENERAL INSTRUCTIONS

1. The question paper consists of two parts, Part A and Part B.
2. There are 20 questions in PART A. Each question is followed by four answers, out of which only one is the correct answer.

Answer all questions in Part A.

3. Answers to Part A are to be marked in the OMR sheet provided.
4. For each question darken the appropriate bubble to indicate your answer.
5. Use only HB pencils for bubbling answers.
6. Mark only one bubble per question. If you mark more than one bubble, the question will be evaluated as incorrect.
7. If you wish to change your answer, please erase the existing mark completely before marking the other bubble.
8. Answers to Part B are to be written in the separate answer book provided.
9. There are 6 questions in PART B.

Answer any FIVE questions in Part B

10. Candidates are asked to fill in the required fields on the sheet attached to the answer book.
11. There is no negative marking.

PART A

Answer all questions. All questions carry equal weight. (20 x 2 = 40 marks)

1. **A and B** are two vectors **whosc magnitudes** are given **by** A **and** B respectively. The value **of A.(B×A)** is:

   (A) $2AB$

   (B) 0

   (C) A^2B

   (D) 1

2. $P(x)$ is **ihe probability density function of a Gaussian** distribution **given** by (μ, σ) where μ **is** the **mean, and** $\sigma(\neq 0)$ **is the standard deviation.** The **value of** the **expression** $\int^{\infty} P(x)dx$ **is:**

   (A) 0.0

   (B) 0.5

   (C) 1.0

   (D) μ

3. Which **among the following processes involves the** maximum amount **of heat exchangc. Mass** involved in each **case is 1 kg.**

   (A) Evaporation of liquid **water at** 0°C.

   (B) Sublimation of **ice at** 0°C.

   (C) Heating **water by** 1°C **at** 20°C.

   (D) Melting **of ice** at 0°C.

4. **The daily** average **solar radiation incident at** the top of the **atmosphere is highest in**

   (A) January

   (B) March

   (C) June

   (D) September

5. The pressure at ihe center of a cyclone is 950 mb and that outside the cyclone is 1000 inb. What is the rise in sea level below the centre of the cyclone?

(A) 5 cm

(B) 5 m

(C) 9.5 cm

(D) 50 cm

6. The units of geopotential are

(A) L^2T^{-2}

(B) L

(C) ML^2T^{-2}

(D) MLT^{-1}

7. Consider two dry air parcels P1 and P2 which are initially at the same temperature at sea level. Both parcels are lifted to 5 km height. Parcel P1 is in thermal equilibrium with its surroundings while P2 follows an adiabatic process. Given these facts, which of the followings is true at 5 km height:

(A) Temperature of P1 > temperature of P2.

(B) Temperature of P1 < temperature of P2.

(C) Temperature of P1 = temperature of P2.

(D) Information insufficient.

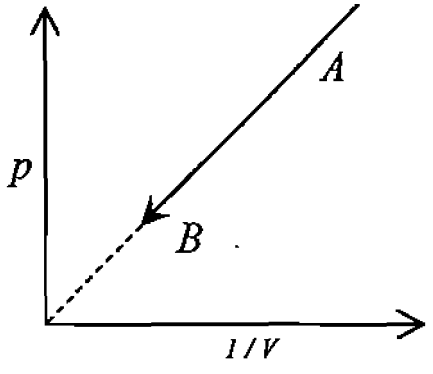
8. The figure shows a thermodynamic process. Find the odd member among the following statements.

(A) Process is adiabatic.

(B) Process is isothermal.

(C) Work is done on the system.

(D) Heat is rejected by the system.



9. The value of the expression $\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} x^3 e^{-\frac{x^2}{2}} dx$ is

(A) 3/2

(B) 0

(C) 1

(D) 3/sqrt(2π)

10. The lowest values of outgoing long wave radiation (OLR) in the tropics correspond to regions of

(A) desert

(B) Amazon forest

(C) clear sky ocean

(D) deep convection

11. Which among the following phenomena has the smallest spatial scale.

(A) Monsoon depression

(B) Hadley Cell

(C) Southern Oscillation

(D) North Atlantic Oscillation

12. If the function $f(x) = 1 + 6\sin^2(2x) - 8\cos^2(x) + \sin(x)$, $0 \le x \le 2\pi$ is expanded in the form $f(x) = \sum_k a_k \sin(kx) + b_k \cos(kx)$ ($k = 0, 1, 2, 3, \ldots \infty$), then all values of a_k and b_k are zero, except

(A) b_0, b_2, b_4, a_1

(B) b_2, b_4, a_1

(C) b_2, b_4, a_0, a_1

(D) none of the above

13. A rock is suspended by a string. The weight of the rock is 10 N. The density of the rock is 4 times that of water. The rock is dipped into a fluid, and the attached spring scale measures a weight of 8 N. The specific gravity of the fluid is

(A) 5/4

(B) 5

(C) 4/5

(D) 4

14. The chemicals responsible for the depletion of ozone actually destroy ozone by reacting with it in the stratosphere. These chemicals include:

(A) chlorine containing compounds

(B) bromine containing compounds

(C) nitrogen oxides

(D) all the above

15. A sharp change in water density near the ocean surface occurs at the

(A) halocline

(B) hydrocline

(C) pycnocline

(D) thermocline

16. Carbon dioxide in the atmosphere is most important as a:

(A) Filter for ultraviolet light

(B) Heat absorber

(C) Reflector of sunlight

(D) Source of latent heat

17. Which of the following relationships between most probable speed (v_p), mean speed (v_m) and root mean square speed (v_{rms}) of an ideal gas can be derived from Maxwell-Boltzmann speed distribution:

(A) $v_p < v_m < v_{rms}$

(B) $v_p > v_m > v_{rms}$

(C) $v_m < v_p < v_{rms}$

(D) $v_{rms} < v_p < v_m$

18. When unsaturated air descends adiabatically without mixing, the following property is constant:

(A) vapour pressure

(B) dewpoint temperature

(C) mixing ratio

(D) relative humidity

19. 10 m height wind speed and direction respectively are 5 m/s and 225° at latitude of 15°N over a tropical ocean. The wind direction at 1 km height is likely to be

(A) 270°

(B) 180°

(C) 360°

(D) 45°

20. Latent heat flux from ocean at a certain time is measured as 250 W m^{-2}. The rate of evaporation in mm day^{-1} is close to

(A) 25.0

(B) 12.5

(C) 8.4

(D) 9.6

END OF PART A

PART B

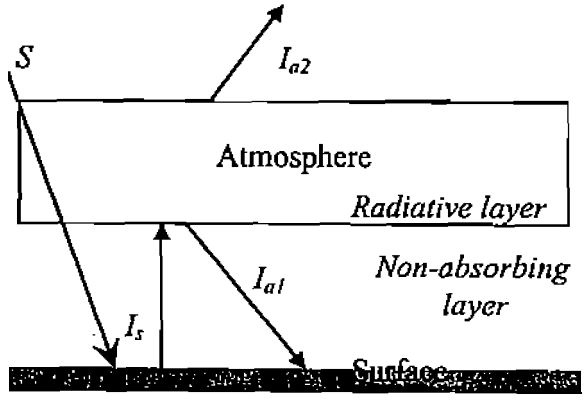
THERE ARE **SIX** QUESTIONS IN THIS **PART.** ANSWER ANY **FIVE.**
ALL QUESTIONS CARRY EQUAL WEIGHT.

(5 x 12 = 60 marks)

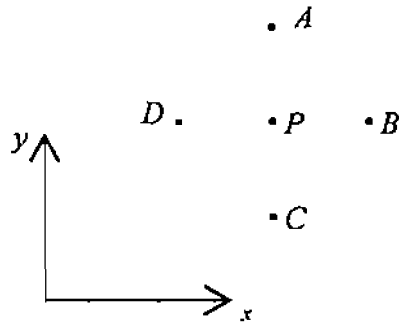
(STATE YOUR ASSUMPTIONS CLEARLY)

1. When there is no atrnosphere and the global mean albedo *(a)* is *0.3,* show that the equilibrium temperature of the Earth is about 255K. For $a = 0.15$, what will be the change in temperature? Calculate the variation in global albedo corresponding to a change in 0.5K in temperature.

2. Consider a planet with an atmosphere which is completely transparent to sunlight while being fully absorbent to infrared radiation. In essence, all the sunlight impinging on the planet (S) passes through to the surface of the planet while the infrared radiation emitted by the surface (I_s) is absorbed by the overlying atmosphere. Of course, the atmosphere in turn also emits infrared radiation (I_{a1}, I_{a2}). This situation is depicied in the figure below. Assuming that the planet's surface and the atmosphere behave as blackbodies and that the sysiem is in thermal equilibrium, find an expression for the surface temperature (T_s) and the temperature of the atmosphere (T_a) in terms of S and σ where S is the incoming solar radiation and σ is the Stefan-Boltzmann constant.



3. (i) We have measurements of the horizontal wind velocity at the points A, B, C and D, which form a square of side $200/\sqrt{2}$ km. The point P is at the centre of the square.



$\underline{u}(A) = 12\hat{i} + 12\hat{j}$

$\underline{u}(B) = 10\hat{i} + 9\hat{j}$

$\underline{u}(C) = 10\hat{i} + 10\hat{j}$

$\underline{u}(D) = 8\hat{i} + 8\hat{j}$,

in metres per second. Estimate the horizontal divergence and the vertical component of vorticity at the point P. If air is assumed incompressible, what can you say about the vertical velocity w? Use MKS units. (*Marks = 6*)

(ii) The horizontal equation of motion (neglecting friction and Coriolis force) is

$$\frac{du}{dt} = -\left(\frac{1}{\rho}\right)\frac{\partial p}{\partial x}$$

If a parcel starts at rest at t=0, and suppose p decreases at the rate of 20 mb per 1000 km, what is the velocity after 15 minutes? Assume the density of air is 1 kg m^{-3}. (*Marks = 6*)

4. In the earth's atmosphere, density varies exponentially with height, so that there is no well defined top of the atmosphere. The scale height is defined as the height where density is e-fold of that at the surface. Now, assume a fictitious atmosphere where density remains constant with heighi and the top of the atmosphere is finite. Show that the height of such a fictitious atmosphere equals to the scale height of the real atmosphere.

5. Thickness of pressure surfaces 100 and 70 hPa is 2.9 km at one location, and 3.0km at a site 500 km to the east. Find the components of the thermal wind vector, given that the Coriolis parameter is 10^{-4} s^{-1}.

6. Change in ocean temperature, in absence of advection, depends on the net flux of energy at its surface. *You* have collected the following data on a given day: the nct flux of energy into the ocean from all sources except evaporation is 300 W m^{-2}; Rate of evaporation at the ocean surface is 8 x 10^{-5} kg m^{-2} s^{-1}. If the net energy is utilized to heat up the upper 10 m of the ocean surface, what is the change in temperature in onc day if latent hcat of evaporation is taken as 2.501 x 10^{6} J kg^{-1}.

END OF PART B