EAS270, "The Atmosphere" Mid-term Exam 27 Oct, 2006

Professor: J.D. Wilson Time available: 50 mins Value: 20%

Instructions: For all 32 multi-choice questions, choose what you consider to be the best (or most logical) option. Use a pencil to mark that choice on the answer form. ***Equations and data given at back***. ***You may keep this exam***

1. Atmospheric pressure is of foremost interest in synoptic meteorology because ____

   (a) it is directly related to mean annual temperature
   (b) it controls humidity and thus cloud formation
   (c) it obeys the hydrostatic law
   (d) it signifies the total mass of air above a pressure-level of 1 mb
   (e) on the synoptic scale it controls the horizontal and vertical winds ✓✓

2. A dim, "watery" sun visible through a gray sheet-like cloud is often a good indication of ____ cloud.

   (a) stratocumulus
   (b) altostratus ✓✓
   (c) nimbostratus
   (d) cirrostratus
   (e) cumulonimbus

3. If cold air is warmed at constant pressure without addition or removal of water vapour, the saturation vapor pressure $e_s(T)$ associated with this air ____ while its relative humidity ____

   (a) increases; increases
   (b) decreases; decreases
   (c) increases; decreases ✓✓
   (d) decreases; increases
   (e) increases; remains unchanged

4. According to the "Geostrophic-wind" and "Gradient-wind" scientific models for the winds in the free atmosphere, the wind should blow ____ to pressure (or height) contours, with a speed that is ____ to the distance between the contours.

   (a) parallel; inversely proportional ✓✓
   (b) parallel; proportional
   (c) perpendicular; inversely proportional
   (d) perpendicular; proportional
   (e) adjacent; indifferent

5. When averaged over a large area (eg. over all of Saskatchewan) at a specific time, the vertical velocity in the free atmosphere is usually ____

   (a) zero
   (b) large and upward
   (c) super-geostrophic
   (d) non-zero, but much smaller than the horizontal velocity ✓✓
   (e) of a magnitude comparable with the horizontal velocity

6. About ____ of the mass of the atmosphere lies below the 500 mb surface, whose distance above sea-level is about ____

   (a) 70%; 3 km
   (b) 50%; 5 km ✓✓
   (c) 50%; 50 km
   (d) 33%; 1 km
   (e) 25%; 50 dam

7. If atmospheric density is 1 kg m^{-3}, then the point of observation must be closest to ____

   (a) 1 mb
   (b) 10 mb
   (c) 100 mb
   (d) 1000 mb ✓✓
   (e) 1000 kPa

8. As a frost protection strategy for a valuable crop the effectiveness of ____ depends on the existence of particular and conducive ('helpfully contributing') meteorological conditions, specifically the presence of

   (a) wind machines; a ground-based inversion ✓✓
   (b) wind machines; an absolutely unstable ground-based layer
   (c) smudge pots; a strong wind
   (d) smudge pots; a layer of nimbostratus
   (e) water droplet sprayers; a ground-based layer in which relative humidity is 100%

9. All terms in the surface energy balance equation are ____

   (a) conductive fluxes
   (b) energy fluxes along the direction of the wind
   (c) energy fluxes along the vertical direction ✓✓
   (d) convective fluxes
   (e) radiative fluxes

10. Consider the alternatives of quantifying the terms in the surface energy balance over periods of 1 or 24 hours (notation: $Q_H^{(1)}, Q_H^{(24)}$, etc., where symbols denote average *rates* of energy transport over the specified interval). Assume the energy balance under discussion is that over a bare soil during a cloudless period in summer. Which of the following statements is *false*?

    (a) the balance $Q^{*(-)} = Q_H^{(-)} + Q_E^{(-)} + Q_G^{(-)}$ is expected to apply in both cases
    (b) $Q_G^{(24)}$ is likely to be smaller in magnitude than the near noon values of $Q_G^{(1)}$
    (c) $Q_H^{(24)}$ is likely to be smaller in magnitude than the near noon values of $Q_H^{(1)}$
    (d) $Q_E^{(1)}$ must always exceed $Q_H^{(1)}$ in magnitude ✓✓
    (e) the "evaporative flux" $E^{(1)} = Q_E^{(1)}/L$ *can* be negative (L is the latent heat of vapourization)

11. The dewpoint of air whose vapour pressure is 12 mb is about ____ Celcius

    (a) 0
    (b) 5
    (c) 10 ✓✓
    (d) 15
    (e) 20

12. Due to the ____ effect, the environmental vapour pressure required to assure the equilibrium of a droplet of pure water of temperature T and radius $R << 1\mu$m ____ the benchmark $e_s(T)$.

    (a) solute; is less than
    (b) solute; exceeds
    (c) Bergeron; equals
    (d) curvature; is less than
    (e) curvature; exceeds ✓✓

13. Suppose in a certain layer of the atmosphere the environmental lapse rate (ELR) is $+0.05^{\circ}\mathrm{C\,m^{-1}}$, ie. for every 1 m increase in altitude, the temperature increases by 0.05°C. This layer is ____

    (a) unconditionally unstable
    (b) conditionally unstable
    (c) conditionally stable
    (d) unconditionally stable ✓✓
    (e) adiabatic

14. A halo around the sun or moon is associated with ____

    (a) nimbostratus
    (b) stratocumulus
    (c) altocumulus
    (d) cirrostratus ✓✓
    (e) altostratus

15. The Bergeron process for migration of water from supercooled droplets to ice crystals depends on the difference in ____ between surfaces of ice and water

    (a) temperature
    (b) equilibrium vapor pressure ✓✓
    (c) density
    (d) terminal velocity
    (e) vertical velocity

16. The ocean surface temperature in the eastern equatorial Pacific is markedly above normal (positive temperature anomaly) during ____

    (a) an Ekman spiral
    (b) a southern oscillation
    (c) a Ferrel cell
    (d) a La Nina
    (e) an El Nino ✓✓

17. At mid-latitudes the predominant winds aloft are ____

    (a) westerly in both hemispheres ✓✓
    (b) easterly in both hemispheres
    (c) meridional in both hemispheres
    (d) meridional in the northern hemisphere, zonal in the southern
    (e) zonal in the northern hemisphere, meridional in the southern

18. Which association is *incorrect*?

    (a) atmospheric window - satellite cloud imagery
    (b) Rossby wave - mesoscale phenomenon ✓✓
    (c) overrunning - airmass boundary
    (d) lee trough - Chinook wind
    (e) southern oscillation - El Nino

19. Which of the following air properties would normally increase as you travelled upward through the summer, daytime Planetary Boundary Layer (Friction Layer)?

    (a) air density
    (b) air pressure
    (c) air temperature
    (d) wind speed ✓✓
    (e) humidity

20. On a skew T - log p diagram, these two families of curves run parallel to each other high in the atmosphere:

    (a) isotherms & isobars
    (b) isobars & dry adiabats
    (c) isobars & moist adiabats
    (d) isotherms & dry adiabats
    (e) dry adiabats & moist adiabats ✓✓

21. The numerical value of earth's "solar constant" is about ____

(a) 9.8 [m s^{-2}]
(b) 0.5 [μm]
(c) 1370 [W m^{-2}] ✓✓
(d) 4 [μm]
(e) 500 [W m^2]

22. In a pristine (ie. clean) atmosphere, the sky colour is attributable to ____

(a) Mie scattering by air molecules
(b) preferential absorption of red light
(c) preferential absorption of blue light
(d) preferential Rayleigh scattering of red light
(e) preferential Rayleigh scattering of blue light ✓✓

23. Electromagnetic radiation with wavelength (λ) between about 0.4 and 0.7 μm is ____

(a) ultraviolet light
(b) in the atmospheric window
(c) microwave radiation
(d) in the "visible" waveband of the shortwave spectrum ✓✓
(e) in the near infra-red (NIR) waveband

24. The shortwave reflectivity (or albedo) is defined to be ____

(a) $\frac{K\downarrow}{K\uparrow}$
(b) $\frac{K\uparrow}{K\downarrow}$ ✓✓
(c) K^*
(d) $K^* + L^*$
(e) $\frac{K\uparrow}{L\downarrow}$

25. On a certain sunny summer afternoon the net radiation over a field of bare soil is $Q^* = 500$ W m^{-2}, and the sensible and latent heat fluxes are $Q_H = 180$, $Q_E = 300$ W m^{-2}. The soil heat flux Q_G is ____

(a) 980 W m^{-2}
(b) 480 W m^{-2}
(c) 120 W m^{-2}
(d) 20 W m^{-2} ✓✓
(e) -980 W m^{-2}

26. Collision efficiency for cloud droplets of radius r, R ____

(a) is near unity for $r \ll R$

(b) is near unity for $r \gg R$

(c) is near unity for $r \approx R$

(d) is a maximum in warm clouds

(e) is much smaller than unity for $r \ll R$ and $r \gg R$ ✓✓

For the remaining questions, please refer to the attached charts.

27. Referring to Fig.(1), the isobar pattern in SW Alberta is a/an ____

(a) lee trough ✓✓

(b) Rossby wave trough

(c) frontal trough

(d) continental Polar (cP) trough

(e) anticyclone

28. Dewpoint at the station nearest to the NW corner of Alberta was ____ and the pressure change in the past 3 hours was ____

(a) 9°C; 25 mb fall

(b) 6°C; 25 mb fall

(c) 3°C; 4.7 mb fall

(d) -3°C; 2.5 mb fall ✓✓

(e) falling after an initial rise; 4.7 mb fall

29. Fig.(2) is an analysis at the ____ level. The heavy dashed line is ____

(a) 250 mb; 100% relative humidity contour

(b) 500 mb; 50% relative humidity contour

(c) 700 mb; $T = T_d = 0$°C contour

(d) 850 mb; $T = 0$°C isotherm (ie. freezing contour) ✓✓

(e) surface; freezing contour

30. On Fig.(2) the thermal feature in Alberta is called a ____

(a) Rossby wave

(b) longwave

(c) trough of warm air aloft (or 'trowal') ✓✓

(d) dry adiabat

(e) mid-latitude cyclone

31. The thermal feature on Fig.(2) in Alberta is caused by ____

    (a) incursion into Alberta of an airstream from the SE bringing in martime tropical (mT) air from the SE United States

    (b) strong solar heating in Alberta

    (c) advection onto Alberta of the warm sector of the coastal cyclone

    (d) the release of latent heat as clouds form at this level over Alberta

    (e) adiabatic compression of air descending the eastern slopes of the Rockies ✓✓

32. On Fig.(2) the black-shaded area defined by intersections of height contours and isotherms demarcates a region of ____

    (a) the Polar front

    (b) the Hadley cell

    (c) cold advection

    (d) warm advection ✓✓

    (e) freezing rain

Equations and Data

- $Q^* \ = \ Q_H \ + Q_E \ + Q_G$

  Energy balance on a reference plane at the base of the atmosphere ("surface energy balance")), all fluxes in [W m^{-2}]. Q^* the net radiation, positive if directed towards the surface; Q_H, Q_E the sensible and the latent heat fluxes, positive if directed from the surface towards the atmosphere; Q_G the 'soil' heat flux, positive if directed from the surface into ground/lake/ocean.

- $Q^* = \ K^* \ + L^* \ = K \downarrow - K \uparrow + L \downarrow - L \uparrow$

  The radiation balance on a horizontal reference plane surface. All fluxes are in [$W\ m^{-2}$]. $K \downarrow, K \uparrow$, the incoming and outgoing solar fluxes (net solar, $K^* = K \downarrow - K \uparrow$); and $L \downarrow, L \uparrow$, the incoming and outgoing longwave fluxes (net longwave, $L^* = L \downarrow - L \uparrow$).

Table 1: Saturation vapour pressure $e_s(T)$ [mb] versus temperature T [C].

T	$e_s(T)$	T	$e_s(T)$	T	$e_s(T)$	T	$e_s(T)$	T	$e_s(T)$	T	$e_s(T)$
0	6.11	5	8.72	10	12.27	15	17.04	20	23.37	25	31.67
1	6.57	6	9.35	11	13.12	16	18.17	21	24.86	26	33.61
2	7.05	7	10.01	12	14.02	17	19.37	22	26.43	27	35.65
3	7.58	8	10.72	13	14.97	18	20.63	23	28.09	28	37.80
4	8.13	9	11.47	14	15.98	19	21.96	24	29.83	29	40.06

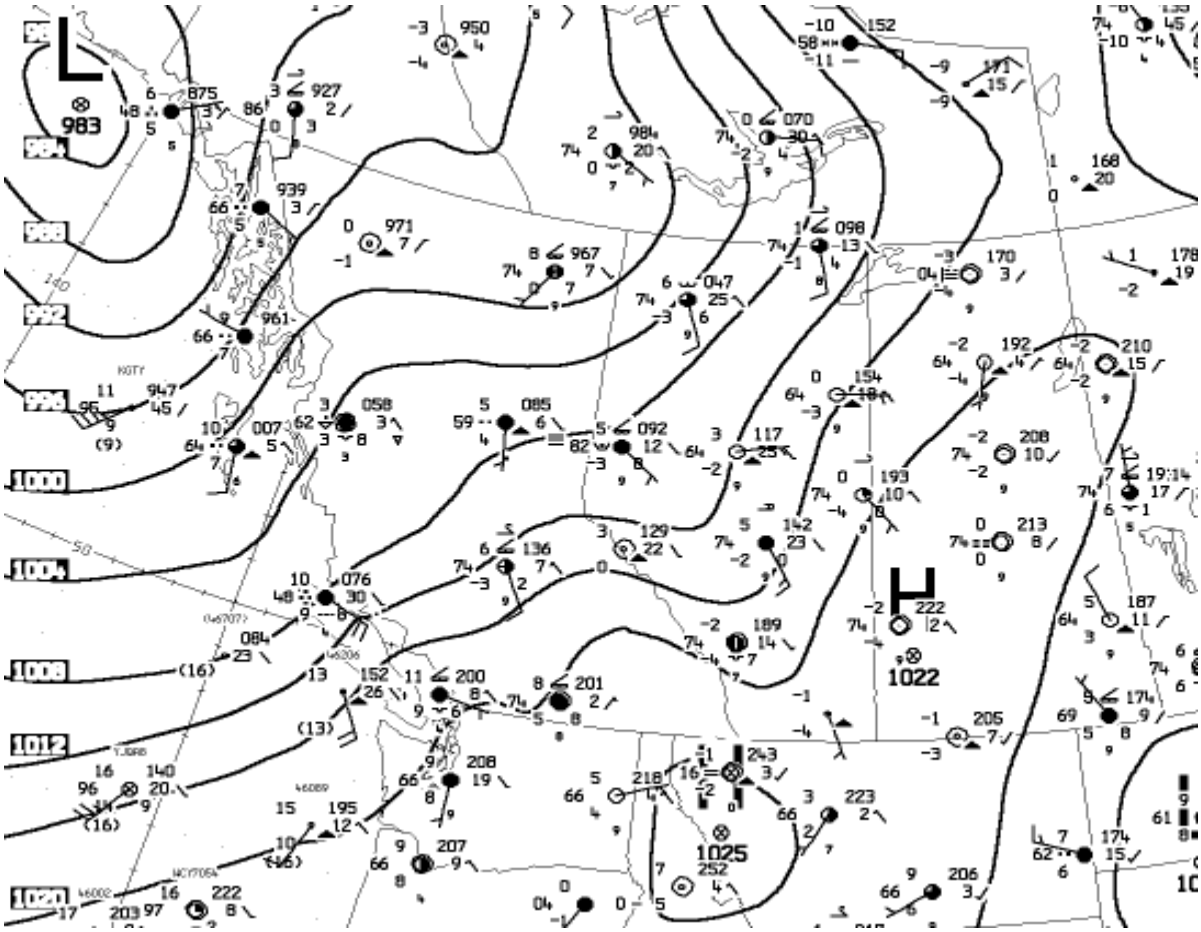

Figure 1: CMC surface analysis, 12Z 12 Oct 2005.

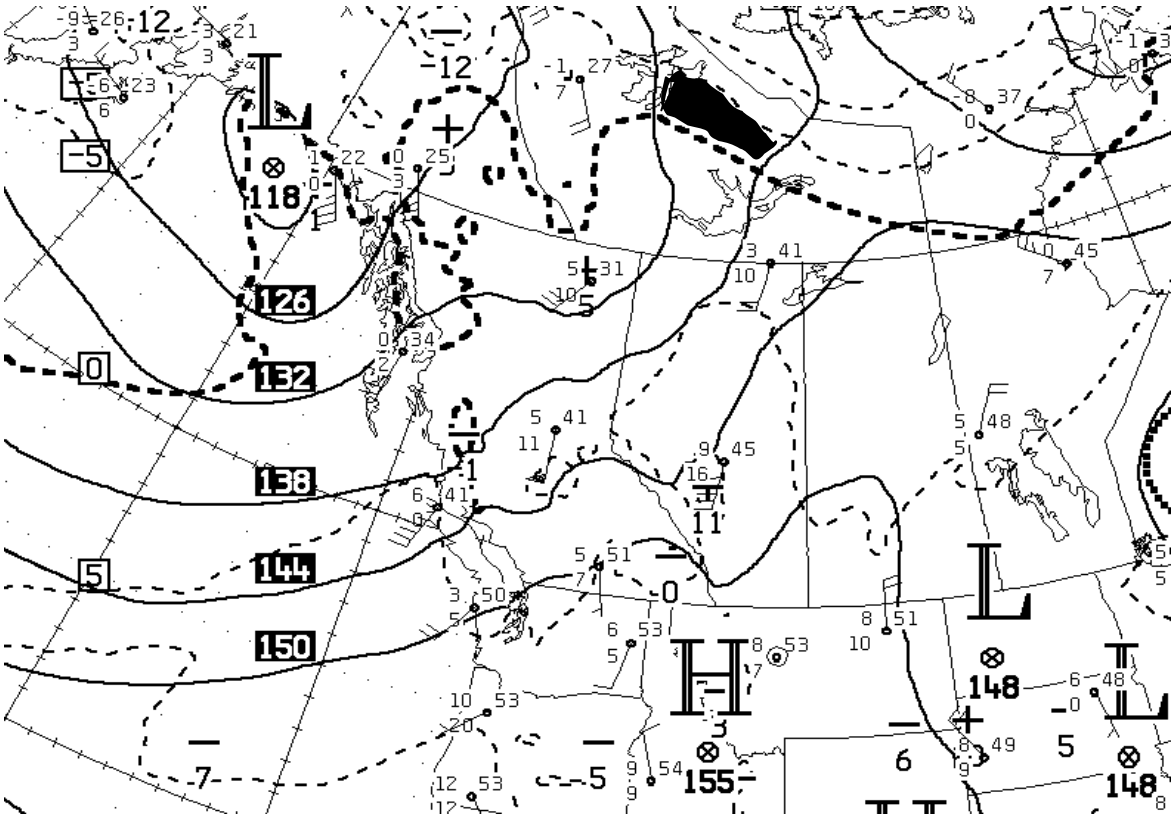

Figure 2: CMC analyses, 12Z 12 Oct 2005.