The effects of magnetic buoyancy on the magnetohydrodynamic stability of model basic states in conducting planetary cores are studied using a simple extension of the Boussinesq rotating magnetohydrodynamic equations. As in the Boussinesq approximation, density variations are considered only in the gravitational force, but the density varies linearly with both temperature and pressure variations. The model is substantially simpler than the fully compressible equations, which include sound waves, the anelastic equations with general density or the anelastic equations with spherical-symmetric steady density. The magnetic induction, momentum, and heat equations in a rotating sphere with electrically insulating exterior are linearised about a steady, stationary basic state with a mean axisymmetric azimuthal magnetic field. The resulting equations for the perturbation magnetic field, velocity and temperature are discretised using vector and tensor spherical harmonics in angle and finite-differences in radius. Vector spherical harmonic representations are used for the basic state vector fields as well as the interaction terms in the equations. The solenoidal property of the perturbation magnetic and velocity fields are imposed on the fields and equations using relations between vector spherical harmonics and toroidal-poloidal representations. The pressure is determined from the horizontal divergence momentum equation. The resulting generalized eigenproblem is solved using inverse iteration and Newton's method. Results for magnetic stability (with vanishing modified Rayleigh number) problems and magnetoconvective instability are presented for a range of Ekman and Elsasser numbers, different symmetries including azimuthal wavenumber.